VOL. VII, PART IV. *Published July* 21, 1922

# The British Mycological Society

(*Recognosce notum, ignotum inspice*)

# TRANSACTIONS 1920

Edited by

CARLETON REA and J. RAMSBOTTOM

*Price to non-members*, 12/6

CAMBRIDGE
AT THE UNIVERSITY PRESS
1922

# LIST OF OFFICERS AND COUNCIL FOR 1921

*Elected September* 1920

*President*

CARLETON REA, B.C.L., M.A., Hon. memb. Brit. Myc. Socy, etc.

*Vice-Presidents*

Miss GULIELMA LISTER, F.L.S., T. PETCH, B.A., B.Sc.

*Treasurer and Foray Secretary*

A. A. PEARSON, F.L.S.
59, Southwark Street, London, S.E. 1.

*General Secretary*

J. RAMSBOTTOM, M.A., F.L.S., O.B.E.
British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.

*Secretary*

Miss E. M. WAKEFIELD, M.A., F.L.S.
The Herbarium, Royal Botanical Gardens, Kew, Surrey.

*Editors*

CARLETON REA, B.C.L., M.A.
and
J. RAMSBOTTOM, M.A., F.L.S., O.B.E.

## COUNCIL

The OFFICERS, with the following in addition:

W. B. ALLEN, Prof. R. H. BIFFEN, F. T. BROOKS, Prof. A. H. R. BULLER, Miss D. M. CAYLEY, A. D. COTTON, Very Rev. D. PAUL, T. PETCH, Prof. M. C. POTTER, Mrs E. A. REA, Miss A. LORRAIN SMITH, E. W. SWANTON, and H. WAGER.

## SUB-COMMITTEE FOR PLANT PATHOLOGY

F. T. BROOKS, M.A. (*Chairman*)
E. J. BUTLER, C.I.E., D.Sc.
A. D. COTTON, F.L.S. (*Secretary*)
T. PETCH, B.A., B.Sc.
G. H. PETHYBRIDGE, B.Sc., Ph.D.
J. RAMSBOTTOM, M.A., F.L.S.

The President and Secretary of the Society *ex Officio*.

## HASLEMERE, SPRING FORAY.

*May 13th–16th*, 1921.

The spring foray was held at Haslemere, Surrey, during the Whitsuntide Holidays, at the invitation of the Haslemere Natural History Society. About thirty members assembled at the Educational Museum on Friday evening and were received by Mr and Mrs E. W. Swanton and members of the Haslemere Natural History Society. On Saturday morning a start was made from the Museum at 10 o'clock by motor for Verdly woods, Sussex. As was to be expected in consequence of the previous drought very few of the larger fungi were to be found and it cannot be said that the microforms were very abundant. The stroll through the beech woods was enlivened by the visible emission of spores from fruit bodies of *Ganoderma applanatum*. These were on a fallen log on a steep slope and as the ascent was made with the sporophores between the sun and the climbers the spore discharge was remarkably clear.

Sunday morning was left open, but many of the party climbed Blackdown with little or no mycological results. In the afternoon the members left the Museum at 2.30 and visited Valewood Park and woods. A number of species were added of which *Puccinia Epilobii* was perhaps the most interesting. The party was entertained to tea by Mrs Daffarn.

On Monday, after the members had been photographed, a start was made for Blackdown Park. Fungi again were scarce and the day seemed blank for interesting finds, but as the grounds of the house were approached to have tea at the invitation of Lady Philipson-Stow a number of polypores were noticed on the boles of *Abies pectinata*. Some of these were afterwards secured and proved to be *Fomes robustus**, a fungus not previously recorded for this country.

The evenings were spent at the Museum examining the specimens gathered and taking advantage of the mycological exhibits arranged by Mr Swanton to whom the Foray owed its success.

A vote of thanks was awarded to Major the Hon. Harold Pearson for permission to visit Verdly woods and to Mrs Daffarn and Lady Philipson-Stow for their permits and hospitality.

In preparing the following list of species the writer is indebted to the various members of the party for records of their finds, particularly to Mr A. A. Pearson and Mr E. W. Swanton.

* For description see British Basidiomycetae by Carleton Rea, p. 593.

*H* = Haslemere. *V* = Verdly Woods. *P* = Valewood Park. *B* = Blackdown Park.

## HYMENOMYCETES.

Lepiota amianthina (Scop.) Fr. *V.*
Armillaria mellea (rhizomorphs) (Vahl.) Fr. *P.*
Tricholoma flavobrunneum Fr. *V.*, terreum (Schaeff.) Fr. *V.*, gambosum Fr. *H.B.*
Clitocybe phyllophila Fr. *V.*, fragrans (Sow.) Fr. *B.*
Collybia maculata (A. & S.) Fr. *B.*, conigena (Pers.) Bres. *P.B.*
Mycena haematopus (Pers.) Fr. *B.*, polygramma (Bull.) Fr. *B.*, stylobates (Pers.) Fr. *B.*
Omphalia umbellifera (Linn.) Fr. *P.*
Nolanea pascua (Pers.) Fr. *V.P.B.*, proletaria Fr. *V.*
Claudopus variabilis (Pers.) W. G. Sm. *B.*
Pholiota praecox (Pers.) Fr. *P.B.*
Naucoria Cucumis (Pers.) Fr. *P.*
Galera hypnorum (Schrank) Fr. *V.B.*
Stropharia semiglobata (Batsch.) Fr. *P.*, merdaria Fr. *B.*, coronilla (Bull.) Fr. *V.*
Hypholoma fasciculare (Huds.) Fr. *V.*, Candolleanum Fr. *P.*
Psilocybe ericaea (Pers.) Fr. *V.*
Psathyra fibrillosa (Pers.) Fr. *P.*, pennata Fr. *H.*
Panaeolus campanulatus (Linn.) Fr. *V.P.B.*
Psathyrella gracilis Fr. *V.*, atomata Fr. *B.*, disseminata (Pers.) Fr. *B.*
Coprinus cinereus (Schaeff ) Cke. *V.*, radiatus (Bolt.) Fr. *B.*, plicatilis (Curt.) Fr. *V.B.*
Cortinarius hinnuleus (Sow.) Fr. *V.*, leucopus (Bull.) Fr. *V.*
Cantharellus cibarius Fr. *P.*
Panus stypticus (Bull.) Fr. *H.V.*
Lenzites betulina (Linn.) Fr. *P.*
Boletus flavus With. *V.*
Polyporus Schweinitzii Fr. *P.*, amorphus Fr. *P.*, nummularis (Bull.) Quél. *B.*, sulphureus (Bull.) Fr. *P.*, chioneus Fr. *B.*, adustus (Willd.) Fr. *V.*, betulinus (Schrad.) Fr. *V.P.B.*
Ganoderma applanatum (Pers.) Pat. *V.*
*Fomes robustus Karst. *B.*, annosus Fr. *P.*, ferruginosus (Schrad.) Mass. *P.*
Polystictus versicolor (Linn.) Fr. *V.P.B.*, abietinus (Dicks.) Fr. *P.*
Poria viridans Berk. *P.*
Trametes gibbosa (Pers.) Fr. *V.P.*
Daedalea quercina (Linn.) Fr. *V.*
Merulius corium (Pers.) Fr. *P.*
Irpex obliqua (Schrad.) Fr. *V.P.B.*
Stereum hirsutum (Willd.) Fr. *V.P.B.*, rugosum (Pers.) Fr. *P.*
Hymenochaete rubiginosa (Dicks.) Lév. *V.*
Corticium arachnoideum Berk. *V.*, subcoronatum v. Hoehn. & Litsch. lividum (Pers.) Fr. *B.*, (Gloeocystidium) praetermissum (Karst.) Bres. *V.*
Peniophora cremea Bres. *P.*, Aegerita v. Hoehn. & Litsch. *V.*, velutina (DC.) Cke. *P.*, Molleriana (Bres.) Sacc., hydnoides Cke. & Mass. *V.P.*
Hypochnus fumosus Fr. *P.*
Dacryomyces deliquescens (Bull.) Duby *V.*
Lycoperdon pyriforme (Schaeff.) Pers. *B.*, depressum Bon. *B.*, caelatum (Bull.) Fr. *B.*
Exidia glandulosa (Bull.) Fr. *V.*
Bovista plumbea Fr. *B.*, nigrescens Pers. *B.*
Scleroderma verrucosum (Vaill.) Pers. *V.*
Cyathus striatus (Huds.) Pers. *V.*

* *New British Record.*

## UREDINEAE.

Uromyces flectens Lagerh. on *Trifolium repens H.*, Ervi (Wallr.) Westend. on *Vicia hirsuta B.*, Ficariae (Schum.) Lév. on *Ranunculus Ficaria B.*, Acetosae Schroet. *V.*, Scillarum (Grev.) Wint. on *Scilla nonscripta V.*, Dactylidis Otth. *H.*, Poae Rabenh. aecidia on *Ranunculus repens H.*
Puccinia obtegens (Link) Tul. *H.*, Hypochaeridis Oud. *H.*, Taraxaci Plowr. *H.*, Menthae Pers. on *Mentha aquatica V.B.*, Betonicae (A. & S.) DC. *B.*, Primulae (DC.) Duby *V.B.*, Saniculae Grev. *V.*, tumida Grev. on *Carum maius H.*, Epilobii DC. on *Epilobium palustre P.*, pulverulenta Grev. *P.*, Violae (Schum.) DC. on *Viola canina V.P.*, fusca (Relh.) Wint. *B.*, obscura Schroet. on *Luzula sylvatica V.*, Caricis (Schum.) Rebent. aecidia on *Urtica H.*, graminis Pers. on *Poa H.*
Phragmidium Rubi (Pers.) Wint., mucronatum (Pers.) Schlecht. *V.*
Coleosporium Senecionis (Pers.) Fr. *V.*
Pucciniastrum pustulatum (Pers.) Diet. on *Epilobium angustifolium P.*
Melampsora Hypericorum (DC.) Schroet. on *Hypericum Androsaemum V.*
Thecopsora Vacciniorum (Link) Karst. *V.*

## USTILAGINEAE.

Tilletia debaryana Fisch. v. Waldh. on *Holcus mollis H.P.*
Urocystis Anemones (Pers.) Wint. *B.*, Violae (Sow.) Fisch. v. Waldh. *V.B.*

## DISCOMYCETES.

Aleuria vesciculosa (Bull.) Boud. *V.*
Ciliaria scutellata (Linn.) Quél. *V.*
Coprobia granulata (Bull.) Boud. *V.*
Ascobolus glaber Pers. *B.V.*, furfuraceus Pers. *V.B.*, vinosus Berk. *B.*
Dasyobolus immersus (Pers.) Sacc. *B.*
Saccobolus violascens Boud. *V.*
Ascophanus carneus (Pers.) Boud. *V.B.*, lacteus (Cooke & Phill.) Phill. *V.*
Lasiobolus equinus (Mull.) Karst. *V.*
Rhyparobius brunneus Boud. *B.*
Coryne sarcoides (Jacq.) Tul. *B*
Bulgaria inquinans (Pers.) Fr. *V.*
Polydesmia pruinosa (B. & Br.) Boud. *V.*
Orbilia xanthostigma Fr. *V.P.B.*
Sclerotinia Curreyana (Berk.) Karst. (sclerotia) *P.*
Chlorosplenium aeruginosum (Oeder.) de Not. *V.B.*
Helotium herbarum (Pers.) Fr. *B.V.P.*, virgultorum (Wahl.) Karst. *B.*
Dasyscypha virginea (Batsch.) Fuck. *V.*, nivea (Hedw. f.) Sacc. *P.*
Trichoscypha calycina (Schum.) Boud. *V.*
Hyaloscypha hyalina (Pers.) Boud. *V.B.*
Mollisia cinerea (Batsch.) Karst. *V.B.*
Stegia Ilicis Fr. *V.P.B.*
Pseudopeziza Trifolii (Biv. Bern.) Fuck. *B.*
Rhytisma acerinum (Pers.) Fr. *P.*

## PYRENOMYCETES.

Sphaerotheca pannosa Lév. *V.*
Erysiphe cichoracearum DC. *V.*, Polygoni DC. *B.*
Uncinula Aceris (DC.) Sacc. *B.*
Eurotium herbariorum (Wigg.) Link *H.*
Nectria cinnabarina (Tode) Fr. *V.P.*, coccinea (Pers.) Fr. *V.B.*, episphaeria (Tode) Fr. on *Diatrype V.*, Peziza (Tode) Fr. *V.*
Hypomyces rosellus (A. & S.) Tul. *V.B.*, aurantius (Pers.) Tul. *V*
Hypocrea fungicola Karst. on *Polyporus betulinus P.*
Epichloe typhina (Pers.) Tul. on *Holcus, H.*
Sordaria fimicola (Rob.) Ces. & de Not. *V.B.*
Podospora coprophila (Fr.) Wint. *B.*
Sporormia fimetaria de Not. *V.*

Leptospora ovina (Pers.) Fuck. *V.B.*
Bertia moriformis (Tode) de Not. *P.*
Stigmatea Robertiani Fr. *B.*
Sphaerella Pteridis (Desm.) de Not. *V.B.*, maculiformis (Pers.) Auersw. *H.*, hedericola (Desm.) Cooke *V.*
Leptosphaeria Rusci (Wallr.) Sacc. *V.*
Diatrypella quercina (Pers.) Nits. *V.*
Diatrype Stigma (Hoff.) de Not. *B.*, disciformis (Hoffm.) Fr. *B.*
Hypoxylon multiforme Fr. *V.B.*, rubiginosum (Pers.) Fr. *B.*, fuscum (Pers.) Fr. *V.*, coccineum Bull. *V.B.*
Ustulina vulgaris Tul.
Xylaria hypoxylon (Linn.) Grev. *V.P.B.*, polymorpha (Pers.) Grev. *V.B.*
Phyllachora graminis (Pers.) Fuck. *B.*, Junci Fuck. *B.*

## PHYCOMYCETES.

Mucor Mucedo (Linn.) Bref. *H.*, racemosus Fres.
Spinellus fusiger (Link) van Tiegh. *V.*
Rhizopus nigricans Ehrenb. *V.*
Pilaira anomala (Ces.) Schroet. *B.*
Pilobolus crystallinus (Wigg.) Tode *B.*
Piptocephalus Fresiana de Bary *V.B.*
Cystopus candidus (Pers.) Lév. *V.*
Plasmopara nivea (Ung.) Schroet. *P.*
Peronospora Myosotidis de Bary *B.*, Ficariae Tul. *B.*, grisea Ung. on *Veronica Beccabunga H.*

## HYPHOMYCETES.

Ovularia obliqua (Cke.) Oud. *V.P.B.*, primulana Karst. *V.*
Oidium alphitoides Griff. & Maubl. *V.*
Isaria farinosa (Dicks.) Fr. *V.B.*
Acrostalagmus cinnabarinus Cord. *P.*
Trichothecium roseum Fr.
Stysanus Stemonitis (Pers.) Cord. *B.*
Aegerita candida (Pers.) Grev. *V.*
Ramularia Calthae (Cke.) Liro *B.*, Geranii (West.) Fuck. *H.*, variabilis Fuck. *H.*, Taraxaci Karst. *H.B.*

## SPHAEROPSIDEAE.

Phyllosticta hedericola Dur. & Mont. *V.*, Mahoniana (Sacc.) Allesch. *V.*, Cirsii Desm. *B.*
Diplodia Crataegi West. *V.*
Phoma conigena Karst. (Discella strobilina (Desm.) Died.) *V.P.*, Crataegi Sacc. *V.*, samarorum Desm. *B.*, aculeorum Sacc. *V.P.B.*, Urticae Schultz & Sacc. *V.*
Leptothyrium Castaneae (Spr.) Sacc. on *Castanea V.*, var. Quercus C. Massal. on *Quercus V.P.B.*
Septoria Anemones Desm. *B.*, Bellidis Desm. & Rob. *H.V.*, Ficariae Desm. *B.*, graminum Desm. *H.*, Hederae Desm. *V.B.*, Ribis Desm. *V.*, Rubi West. *V.P.B.*

## MYXOMYCETES. (H. J. Howard.)

Ceratiomyxa fruticulosa Macbr.
Physarum nutans Pers. var. leucophaeum Lister, sinuosum Weinm.
Craterium minutum Fr.
Leocarpus fragilis Rost.
Didymium difforme Duby, squamulosum Fr.
Stemonitis fusca Roth.
Comatricha nigra Schroet.
Reticularia Lycoperdon Bull.
Lycogala epidendrum Fr.
Trichia affinis de Bary, persimilis Karst., botrytis Pers.
Arcyria pomiformis Rost., denudata Sheld., incarnata Pers.

# LICHENS OF HASLEMERE DISTRICT.

*By H. H. Knight, M.A.*

Most of the lichens in this list were found growing on trees or palings. There are no exposed rocks in the neighbourhood of Haslemere, and the few saxicolous species were seen on stone walls near farm-houses. A few of these lichens were seen on Hindhead, the majority come from the Sussex woods visited during the meeting.

Chaenotheca melanophaea Zwackh.
Calicium curtum Turn. & Borr.
Collema cheileum Ach.
Leptogium tenuissimum Koerb.
Peltigera canina Willd.
Parmelia physodes Ach.
P. perlata Ach.
P. caperata Ach.
P. saxatilis Ach., form furfuracea Schaer.
P. sulcata Tayl.
P. fuliginosa Nyl. var. laetevirens Nyl.
Cetraria aculeata Fr.
Evernia prunastri Ach.
Usnea florida Web., var. hirta Ach.
U. plicata Web.
Xanthoria parietina Th. Fr.
X. polycarpa Oliv.
X. lychnea Th. Fr.
Physcia hispida Tuckerm.
Lecanora muralis Schaer.
L. subfusca Ach, var. chlarona Ach.
L. atra Ach.
L. galactina Ach.
L. varia Ach.
L. conizaea Nyl.
L. symmictera Nyl.
L. sulphurea Ach.
L. parella Ach.
Pertusaria faginea Leight.
P. pertusa Dal. Tor. & Sarnth.
P. leioplaca Schaer.
P. Wulfenii DC.
Diploschistes scruposus Norm.
Baeomyces rufus DC.
Cladonia sylvatica Hoffm.
C. pyxidata Hoffm.
C. fimbriata Fr.
C. squamosa Hoffm.
C. Floerkeana Fr.
Lecidea ostreata Schaer.
L. granulosa Schaer.
L. uliginosa Ach.
L. fuliginea Ach.
L. parasema Ach.
L. latypea Ach.
L. crustulata Koerb.
L. sylvicola var. infidula Cromb.
Biatorina Griffithii Massal.
B. synothea Koerb.
Bacidia atrogrisea Arn.
Buellia myriocarpa Mudd.
Rhizocarpum confervoides DC.
Arthonia radiata var. Swartziana Sydow.
Opegrapha herpetica Ach.
O. atra Pers.
O. betulina Sm.
O. vulgata Ach.
Graphis elegans Ach.
G. scripta Ach.
Phaeographis inusta Muell.-Arg.
P. dendritica Muell.-Arg.
Enterographa crassa Fée.
Acrocordia gemmata Koerb.
Arthopyrenia fallax Arn.
Porina carpinea A. Zahlbr.
Pyrenula nitida Ach.

# THE BASIDIAL AND OIDIAL FRUIT-BODIES OF DACRYOMYCES DELIQUESCENS.

*By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.*

*Dacryomyces deliquescens* is a very common fungus in England and appears during wet weather upon the surface of dead wood, such as old logs, rails, garden seats, gate-posts, etc.; but it was imperfectly described by the older systematists and by Massee, and its true nature is still misunderstood by many field mycologists. Tulasne* studied its life-history and made the discovery (since confirmed by Brefeld†) that it produces two kinds of fruit-bodies which can be readily distinguished with the naked eye owing to colour differences: (1) orange fruit-bodies, and (2) pale yellow fruit-bodies. Both are gelatinous. The orange fruit-bodies produce oidia and the yellow fruit-bodies basidiospores. The orange fruit-bodies were originally described as *Dacryomyces stillatus* Nees and the yellow fruit-bodies as *Dacryomyces deliquescens* Duby; and this erroneous division of one species into two is still generally retained in systematic hand-books. To clear up the confusion which has thus arisen, I shall now re-describe *Dacryomyces deliquescens* from my own observations.

The orange fruit-bodies are small, rounded or hemispherical, 1–4 mm. in diameter and 1–2 mm. high, occurring in groups of more or less isolated individuals in lines along the grain of the woody substratum and often on its upper side so that they attract the eye. The yellow fruit-bodies are about the same size as the red ones, rounded, hemispherical or discoid, often somewhat wrinkled into folds at the surface especially where two or more fruit-bodies have anastomosed during development, and occurring like the red fruit-bodies in groups of more or less isolated individuals in lines along the grain of the woody substratum and often on its upper surface. In dry weather both the orange and the pale yellow fruit-bodies shrink very greatly, owing to loss of water, and become quite inconspicuous and difficult to find. When rain comes again, the fruit-bodies rapidly absorb water by imbibition and regain their former size and colour. There are few other fruit-bodies so dependent on atmospheric conditions as these.

In nature, the orange fruit-bodies often appear on the surface of wood in groups by themselves. The yellow fruit-bodies also

* L. R. Tulasne, Observations sur l'organisation des Trémellinées, Ann. des sci. nat., Bot., t. XIX, 1853, p. 211.

† O Brefeld, Untersuchungen, Leipzig, 1888, pp. 141–152.

often appear on the surface of wood in groups by themselves. Sometimes, however, patches of red and patches of yellow fruit-bodies appear near to one another on the same piece of wood but not intermingled; and, finally, sometimes red and yellow fruit-bodies appear on wood intermingled promiscuously. According to Tulasne, yellow fruit-bodies may be found, which have red spots upon them or which are gradually changing into red fruit-bodies*. The reason for these variations in the distribution of the two kinds of fruit-body under natural conditions is not yet understood, but the production of one kind of fruit-body rather than another doubtless depends on the physiological condition—possibly the nuclear state—of the underlying mycelium†.

An orange fruit-body has a gelatinous matrix derived from the swollen outer confluent hyphal walls, and this matrix, while firm toward its centre, is more and more readily deliquescent in wet weather as one passes toward its periphery. A fruit-body consists of two parts—an inner, firmer, paler core attached to the substratum, and an outer, more softly gelatinous, thick, bright orange, exterior coating. The core contains pale, thin, branched, anastomosing hyphae which run toward the periphery of the fruit-body and there thicken and give rise to branched chains of pale orange oidia. Thus the thick orange outer coating of the fruit-body comes to be made up of oidia which are embedded in very soft jelly, and its colour is entirely due to the colour of the oidia. The oidia consist of one or two cells and show all stages of detachment from one another. Those on the very exterior of the fruit-body sometimes produce tiny conidia which project into the air. When rain comes, the outer part of the orange oidial zone deliquesces, i.e. the jelly absorbs so much water that it becomes liquid and flows. Thus during rain a large number of the outer oidia are washed away from the fruit-body and become dispersed. However, the production of oidia by the hyphae of the core is long continued so that new oidia gradually take the place of those previously washed away. It thus appears that the orange fruit-bodies are specialised for producing oidia and do not as a rule give rise to any basidiospores.

A yellow fruit-body, like a red one, has a soft gelatinous matrix derived from the swollen outer confluent hyphal walls. This matrix contains and envelops slender, branching, anastomosing hyphae which, toward the periphery of the fruit-body, branch and re-branch to produce the basidia which make up the

* L. R. Tulasne, *loc. cit.*, pp. 216–218, Pl. 13, fig. 2.

† Cf. P. A. Dangeard, Mémoire sur la reproduction sexuelle des Basidiomycètes, Le Botaniste, t. IV, 1895, pp. 136–143.

hymenium. Each basidium has a body which is slender and cylindrical and which develops at its apex two stout divergent arms or sterigmata, the tips of which come to penetrate through the surface of the gelatinous matrix. Each sterigma produces at its free tip a single, elongated, curved spore which is provided with a well-marked hilum. The time taken for a spore to develop from a just recognisable rudiment to full size is only about 23 minutes. After a further 27 minutes the spore is discharged. Thus about 50 minutes only are taken up in the development, ripening, and discharge of each spore. There can be little doubt that this rapid rate of coming to maturity for each individual spore is a factor in assisting a revived fruit-body in rapidly resuming its spore-discharging function after rain. The drop excreted at the hilum begins to appear about 16 seconds before the spore is discharged, grows until it attains the diameter of the spore, and is then carried away by the spore when this is shot from its sterigma. A spore can be shot out from its sterigma 0·5–0·65 mm., so that although the hymenium often looks upwards, the wind has an opportunity of carrying away the spores before they can fall back on the hymenium.

Massee*, in his "British Fungus-Flora," describes the yellow fruit-bodies of *Dacryomyces deliquescens* as follows:

"*Dacryomyces deliquescens* Duby.

Gelatinous, rounded or irregular, convex, gyrose, yellow, hyaline, basal portion root-like and entering the matrix, spores cylindrical, obtuse, curved, 3-septate, 15–17 × 6–7 $\mu$.

*Dacryomyces deliquescens.* Duby, Bot. Gall., p. 729; Cke., Hdbk., p. 351.

On pine-wood. In perfection during the winter months. Forming yellow subcircular convex masses 1–4 lines broad, often growing in long lines out of cracks in the wood."

Massee's statement that the spores are 3-septate is misleading. The fact is that the spores, when on their sterigmata and immediately after discharge, are *unicellular* just like those of other Tremellineae, and only become 3-septate and 4-celled when lying in water and preparing to germinate. The spores of several other Tremellineae behave similarly†.

Massee says that the fruit-bodies occur on pine-wood. That is true, but my experience is that they occur on various kinds

* G. Massee, British Fungus-Flora, London, 1892, vol. 1, p. 67.

† In his illustration of a basidium of *Dacryopsis nuda* Mass. in his British Fungus-Flora (vol. 1, p. 56), Massee represents the spores on the sterigmata as 3-septate and 4-celled. It is not unlikely that this is an error and that the spores on the sterigmata should have been represented as unicellular. Massee may have found isolated spores lying on the hymenium which had become 3-septate after discharge and have then supposed that they were 3-septate before discharge.

of wood both hard and soft, but especially on coniferous woods. Massee says that the fruit-bodies are 1–4 lines wide. These measurements seem to me a little too large. As Massee says, the fruit-bodies are yellow. However, I find that the fruit-bodies most exposed to the light are the yellowest, and that those which grow under logs and boards and in other very dark situations are relatively very pale yellow and sometimes almost colourless.

Massee*, in his "British Fungus-Flora," describes the red fruit-bodies of *Dacryomyces deliquescens* as follows:

"*Dacryomyces stillatus* Nees.

Gelatinous, rounded, convex, more or less plicate, persistently orange; spores cylindrical, curved, and multiseptate, 18–22 × 7–8 μ.

*Dacryomyces stillatus*. Nees, Syst., p. 89, f. 90; Cke., Hdbk., p. 352.

On pine and other decaying wood. Distinguished from *D. deliquescens* by its rather small size, firmer substance, deeper orange colour, and larger, multiseptate spores. Usually barren."

Massee describes these red fruit-bodies as being more or less plicate. My experience is that they are mostly hemispherical and irregularly humped or obtusely tuberculate rather than plicate. He also says: "spores cylindrical, curved, multiseptate, 18–22 × 7–8 μ," but he fails to tell his readers that by 'spores' he means not basidiospores, but *oidia* embedded in the gelatinous outer layer of the fruit-body. Each oidium has at least one septum across it, but the oidia hang together in chains and show all stages of separation from one another. Only the chains of oidia are multiseptate. The width of the oidia I find to be 2–4 μ and not 7–8 μ. They are but rarely as wide as the basidiospores. The 2-celled oidia are 12–15 μ long, but chains of these oidia imperfectly separated from one another may be 45 μ or even 60 μ long. The oidia are usually curved or undulate and are sometimes more or less Y-shaped. In each cell there are usually two small central rounded bright spots, so that the chains of cells are guttulate. The oidia on the exterior of the fruit-body produce a few tiny oval conidia about 2 μ long. If a red fruit-body be touched into a drop of water on a slide, some of these conidia can usually be found in the drop among the oidia, and occasionally one may find them attached to their oidia. Massee says that the fruit-bodies are "usually barren." Exactly what is meant by this is not clear. As a matter of fact the red fruit-bodies always produce a crop of oidia and never any basidiospores.

* G. Massee, *loc. cit.*, p. 67.

A brief description of *Dacryomyces deliquescens*, suited for systematic purposes, is as follows:

### ***Dacryomyces deliquescens*** Duby.

Synonym for the oidial stage: *Dacryomyces stillatus* Nees.

*Basidial fruit-body*—gelatinous, convex, rounded, or irregular when confluent, often slightly plicate or gyrose, yellow, translucent, 1–6 mm. in diameter, basal portion emerging from the wood at the central point. Basidiospores cylindrical, curved, obtuse, 12–15 × 5–6 $\mu$, 1-celled when discharged from the sterigmata but after lying in water soon becoming triseptate and 4-celled.

*Oidial fruit-body*—gelatinous, convex, mostly hemispherical, not plicate but when large often irregularly humped up at the surface, bright orange, rather opaque, 1–3 mm. in diameter, basal portion as before. Basidiospores never present. Oidia very numerous, embedded in the outer gelatinous layer which deliquesces in rainy weather and sets them free, formed in branching chains, cylindrical, curved or flexuose, sometimes forked, usually 2-celled but forming chains owing to imperfect separation, width 2–4 $\mu$, length when 2-celled 12–15 $\mu$, but forming chains up to 60 $\mu$ long, sometimes bearing one or two minute oval conidia 2 $\mu$ long, contents pale orange with one or two clear guttules in each cell.

Lignicolous, occurring on many different kinds of wood especially coniferous woods. Common everywhere, often seen in gardens on old pine boards, wooden rails, arbour-work, etc. It is to be found all the year round but is conspicuous only in wet weather.

The two forms of fruit-bodies were originally described by Duby and Nees as independent species and have always been so treated by systematists, the basidial form being called *Dacryomyces deliquescens* and the oidial form *D. stillatus*; but Brefeld has proved that they are nothing but two stages of the same species. They may be found separated from one another on different substrata, or in separate patches side by side on the same substratum, or occasionally intermingled. According to Tulasne some of the yellow fruit-bodies may at times be marked with red patches of the same nature as the red fruit-bodies.

# SOME WOOD-STAINING FUNGI.

With Plates VIII and IX.

*By B. D. MacCallum, M.A., D.Sc., F.L.S.*

## I. *Ceratostomella Piceae* Münch.

The first recorded observation of the cause of "blue-rot" in timber was made by Hartig(1), who noted that the "blueing" of pine-wood was due to the brown mycelium of a fungus which rapidly penetrated the whole trunk with the exception of the heart-wood. This fungus he described under the name of *Ceratostoma piliferum*. Saccardo(5) proposed the new genus *Ceratostomella* for all species with colourless ascospores.

In 1903 investigation of the "blueing" of pine timber began in America, and von Schrenk(6) submitted a report on it to the U.S. Department of Agriculture. He describes the perithecia of *Ceratostomella pilifera* Wint. as they occur on the wood of *Pinus ponderosa* and in artificial culture, and mentions the occurrence of conidial forms, but his investigations of these was unfinished. He was of opinion that the entrance of the fungi into the trunks of standing trees was through the galleries made by the bark beetle (*Dendroctonus ponderosae*), but it was to the attacks of the beetle and not of the fungus that he attributed the death of the trees. The paper also gives the result of tests of the strength and durability of the blue wood.

In 1906, Hedgcock(2) took up the work where von Schrenk had left it, and published the result of his investigation on "Chromogenic fungi which discolour wood," wherein he described numerous species of *Ceratostomella*, describing both conidial forms and perithecia, and, in addition, gave an account of other wood-staining fungi under the genera—*Graphium*, *Hormodendron*, *Hormiscium* and *Penicillium*.

In 1907, Ernst Münch(4) published "Die Blaufäule des Nadelholzes"—a paper embodying the result of most careful investigation of the genus *Ceratostomella*. Münch is of opinion that *Ceratostomella pilifera* Wint. must be regarded as a composite species and describes three of the constituent species—*C. Piceae*, *C. cana* and *C. coerulea*; a further species, *C. Pini*, is sharply marked off from the others by its much smaller, short-necked perithecium. The perithecia of the "pilifera group" are all of the same type, and these species differ only in their auxiliary fruit-forms.

In addition, Münch describes a new species, *Endoconidiophora coerulescens*, of which he says "As to another fungus (hitherto

included in *C. pilifera*) the perithecia of which are very like those of the three previously named (i.e. those of the 'pilifera group'), this must, on account of its characteristic auxiliary fructifications, form another genus."

The latest contribution to the literature of the subject is "Some Notes on Sap-stain Fungi," by E. E. Hubert(3). This is a description of the action of the fungi on the timber of various trees and the results of tests of the strength of the infected timber.

In this country "blue-rot" has been known for many years, and it has been assumed that it is caused by one or more species of *Ceratostomella*, but I have been unable to find any description of species occurring here. The present investigation has not been confined to *Ceratostomella*, for it was found that, in many cases, even where the characteristic blue stain was most pronounced, other fungi were present.

Pl. VIII is a photograph of a section of the trunk of a freshly-felled tree of *Pinus sylvestris*. At every point where the trunk and the branches were cut there was a well-defined blue band—the infected sap-wood—which was riddled with a network of brown hyphae (Pl. IX, fig. 1). From this wood several fungi were isolated, including two species of *Ceratostomella*. It is clear that the isolation of the components of such a mixed infection is a matter of considerable difficulty.

Of the genus *Ceratostomella*, I have found *C. Pini* Münch and *C. Piceae* Münch very commonly in and around Edinburgh and, indeed, in any woods visited between Edinburgh and Inverness, and have no doubt that they occur all over Scotland.

In Edinburgh it is so abundant that in any load of household wood (if it is of *Pinus sylvestris*) perithecia may be observed on almost every log, crowded in the cracks of the bark and on the surface of the wood. In some cases the sap-wood of standing trees was found badly attacked by these two species of *Ceratostomella* and other fungi, and it is interesting to note that in all cases which have come under my observation the bark of the tree was riddled with the holes made by the pine beetle (*Hylesinus piniperda*). This would appear to support von Schrenk's theory for the cause of death of the "blued" specimens of *Pinus ponderosa*.

Another point which may, perhaps, be of importance is that the dead trees were generally in marshy ground.

### *Ceratostomella Piceae* Münch.

This fungus has been described by Münch as it occurs in Bavaria, but I am commencing my description of the wood-staining fungi with a short account of its life-history, as it

occurs so commonly in Great Britain, although it has not been recorded, and Münch's paper is not readily accessible. It is perhaps the easiest species to study, for although it is almost inextricably entangled with other fungi on *Pinus sylvestris* it produces a nearly "pure" growth on *Picea excelsa*. However, it may easily be overlooked, as the timber of the spruce is quite unstained. Münch is not quite certain how far *C. Piceae* stains wood, but states that fallen timber is sometimes blue, sometimes slightly darkened and sometimes quite unstained. So far as my observations go, in Scotland spruce timber is quite unstained even when perithecia occur thickly all over the surface, and, although *C. Piceae* occurs very frequently on badly stained *Pinus sylvestris*, I have never found it unaccompanied by other fungi. Moreover, pure cultures on sterilised pine blocks caused only a very slight discoloration. Certainly there was no trace of the characteristic blue colour always associated with attacks of *C. Pini*.

The principal media used for the cultivation of the fungus have been pine and spruce decoction agar (or gelatine) and plum agar. Very successful growths also were made on sterile blocks of moist sap-wood in deep Petri dishes or narrow strips in test tubes.

Fully developed perithecia were found throughout the autumn, and from the sticky mass on the top of the beak, streak cultures of ascospores were made. The ascospores germinate readily, and, after two days, a small mycelium of delicate, white, branching hyphae is formed. At the end of the second day conidia begin to appear, and on the third day the mycelium has produced numerous conidiophores, bearing conidia of the Cladosporium type (Pl. IX, fig. 2).

The conidiophores, which arise in the submerged part of the mycelium as well as aerially, are sometimes single and short, but more often they branch, the most characteristic form consisting of a fairly long stalk-like portion, from the end of which four to six branches radiate out, and these branches may branch again or conidia may be abstricted from their ends (Pl. IX, fig. 2). The whole conidiophore breaks up very readily and the conidia bud on the surface of the agar forming a yeast-like mass.

The size of the conidia varies enormously, the length being 4–15 $\mu$, the width 2·5–3·5 $\mu$.

In hanging drops of pine decoction the mycelium may produce conidiophores of this type, but more often there is a simple conidiophore, at the apex of which a whorl of conidia is formed (Pl. IX, fig. 2 *b*). These conidia vary very little in size, being 6–8 $\mu$ long and 2·5–3·5 $\mu$ wide.

In weak pine-decoction agar or gelatine, conidia of this second

type appear frequently, and another common form is that depicted in Pl. IX, fig. 2 *c*. In almost any culture also, conidia may arise from the mycelium without the formation of a conidiophore.

As the mycelium increases in size, strands of hyphae of a considerable thickness are often formed, and parts of these become at times almost black. They are often covered with a mass of conidia. From these coremia, as from the ordinary mycelium, conidia may arise without the production of a conidiophore. About the fourth day a new type of fructification arises—the Graphium form, which, as Münch notes, is probably the *Graphium penicillioides* Corda. The Graphia appear in great numbers along the streaks and are easily visible to the naked eye as stout cylindrical pillars surmounted by a spherical head (Pl. IX, fig. 4). Each one arises from a group of short swollen cells of the mycelium, numerous branches of which grow up together to form a thick strand, the lower part of which becomes quite black, while the upper part remains colourless. The hyphae forming this stalk are very narrow and not infrequently the outer cells are slightly twisted round the stalk (Pl. IX, fig. 4 *a*). The apex is at first pointed but later spreads out, the colourless hyphae branching and from these branches the very small (3–4 $\mu$ long, 1·5–1·75 $\mu$ wide) colourless conidia are cut off. When the Graphium is mature the head consists of a drop, milky below where the spores are collected but quite clear above. This drop, unlike that on the beak of the perithecium, mixes quite readily with water.

In older cultures, small Graphia often grow out from the main head, while the Cladosporium conidiophores may sprout from the stalk, producing a most complicated looking structure. At the end of two weeks, perithecia begin to appear, a perithecium often arising at the base of a Graphium. The time of appearance of the perithecia however, is rather variable, for sometimes without any apparent difference of conditions, they have been delayed until the sixth week, and, as Münch also found, their number is very variable, some cultures being studded thickly with perithecia, while others on the same media and under the same conditions, produce only a few. I have even had some without perithecia at all but with an enormous growth of mycelium. If, however, a piece of this mycelium was transferred to another agar plate perithecia were invariably produced.

The perithecium commences as a tangled mass of hyphae which are first a light, then a very dark brown, and finally decidedly black. For some time it grows as a dark spherical body invested with very fine, light-brown, hair-like hyphae. From its upper surface the beak then arises as a cylindrical

sheaf of narrow parallel hyphae slightly bent towards the end. The beak is black except at the tip where it is colourless (Pl. IX, fig. 7 *a*). At maturity the tip opens out to form a crown of bristles supporting the shiny yellowish mass of ascospores.

The diameter of the perithecium is 150–250 $\mu$, the neck varies from ·85–1 mm. in length (though on *Pinus sylvestris* it is sometimes 1·2 mm. or more in length), 20–40 $\mu$ in width. The asci that I have found, agree with the description of Münch, not with that of von Schrenk or Hedgcock, but I have found them only occasionally and after much search, though Münch found them most abundantly. The ascus is almost spherical, 4·5–6 $\mu$ in diameter. It has an extremely delicate wall and in crush preparations it generally collapses. Münch finds 6–8 ascospores. I have found eight, apparently in two groups of four. The ascospores are 3–4·5 $\mu$ long, slightly curved, and rounded at both ends.

All attempts to isolate a single ascospore were barren, as no solvent of the slime could be found which did not destroy the ascospore, so that streak cultures only could be made and young single mycelia isolated from their ends and transferred to separate plates. This was done repeatedly and the same series resulted in all cases.

Cultures were also made from single spores of the Graphium, but with a disappointing result, for only the usual conidial forms and no perithecia were produced. Münch had exactly similar results and he acknowledges that this is very much against the theory that the Graphium is a stage in the life history of *C. Piceae*.

Just recently I have been making cultures from single conidia of the Cladosporium type, and in several cases have produced perithecia as well as Graphia. As I have had this result in only a few cultures, at the present moment I am willing to admit that this piece of evidence is not complete. Lack of time for research has prevented my repeating these rather tedious single spore cultivations, but I hope to do so at a later date.

It is clear that, if this result can be obtained in a sufficiently large number of cultures from a single conidium, there can be absolutely no objection to the inclusion of *Graphium penicillioides* as a stage in the life-history of *Ceratostomella Piceae*. Like Münch however, I am convinced that I have isolated numerous ascospores after germination and in each of these, have observed the same series of conidial and perithecial forms; namely, the Cladosporium type of conidiophore, followed by the Graphium fructification, these arising within a few days of germination, and finally, after two weeks or more, the perithecium.

The above description, of course, applies to cultures of

*C. Piceae* in artificial media. On the spruce a rather small mycelium is produced and it does not penetrate very far into the wood. It is white or slightly greenish in colour and produces on the surface the same conidial forms and perithecia as in artificial culture. The Graphia are extremely numerous, but the perithecia vary in number, sometimes studding the wood closely, sometimes appearing singly here and there among the Graphia.

## Summary.

In my investigation of *Ceratostomella Piceae* Münch, my results are similar to those of Münch, that is that *Graphium penicillioides* Corda must be considered a stage in the life-history of *Ceratostomella Piceae.*

## BIBLIOGRAPHY.

(1) Hartig, R.—Lehrbuch der Pflanzenkrankheiten, pp. 75 and 106, 1900.
(2) Hedgcock, G. G.—Studies upon some Chromogenic Fungi which discolour wood. Missouri Botanical Garden. Seventeenth Annual Report, St Louis, 1906.
(3) Hubert, E. E.—Notes on Sap-stain Fungi. Phytopathology, 11 (1921).
(4) Münch, E.—Die Blaufäule des Nadelholzes in Naturwissenschaftlichen Zeitschrift für Forst und Landwirtschaft, 1907–1908.
(5) Saccardo, P. A.—Michelia, 1. p. 370, 1878. Sylloge Fungorum, I–XVII.
(6) Von Schrenk, H.—The "blueing" and the red rot of the Yellow Western Pine. U.S. Dept. of Agriculture, Bureau of Plant Industry Bulletin, No. 36, Washington, 1903.

## DESCRIPTION OF PLATES.

Plate VIII. Photograph of transverse section of the trunk of a freshly felled tree of *Pinus sylvestris* showing sap-wood stained deep blue—in places nearly black—by a mixed infection of fungi.

Plate IX. Fig. 1. Section of sap-wood of Plate VIII showing brown hyphae of fungi running along tracheides and filling medullary rays. ×800. Wide hyphae are often found where cells of medullary ray are destroyed.

Figs. 2–7. Ceratostomella Piceae.

Fig. 2. (*a*) Mycelium from germinating ascospore showing conidiophore of usual Cladosporium type. ×400. (*b*), (*c*), (*d*) Conidia from hanging drops of weak pine and spruce decoction.

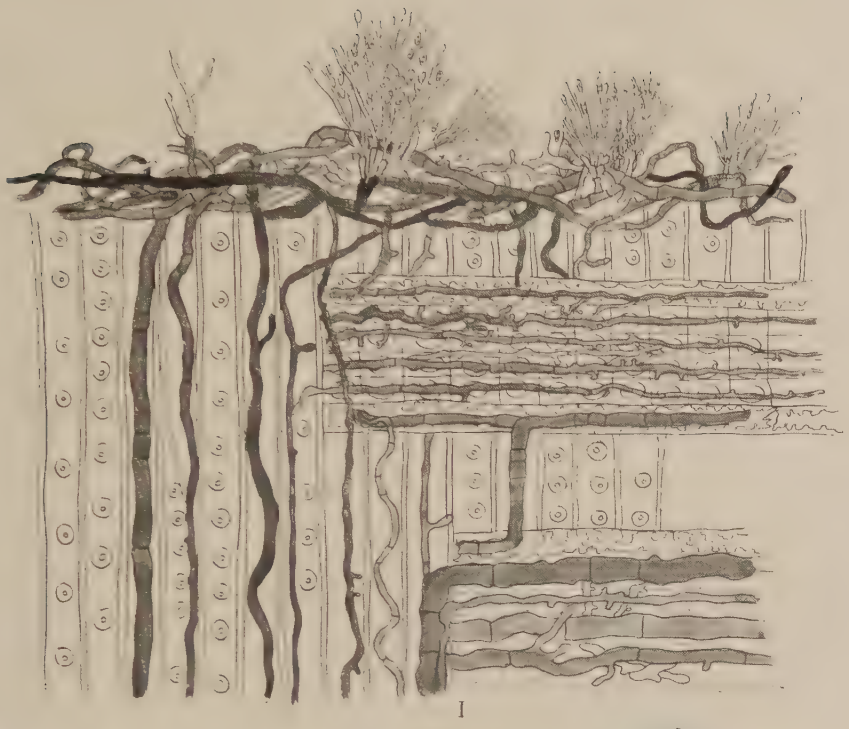
Fig. 3. Row of beaded mycelial cells from which young Graphia arise, the mooring hyphae are conspicuously brown in the more or less colourless mycelium.

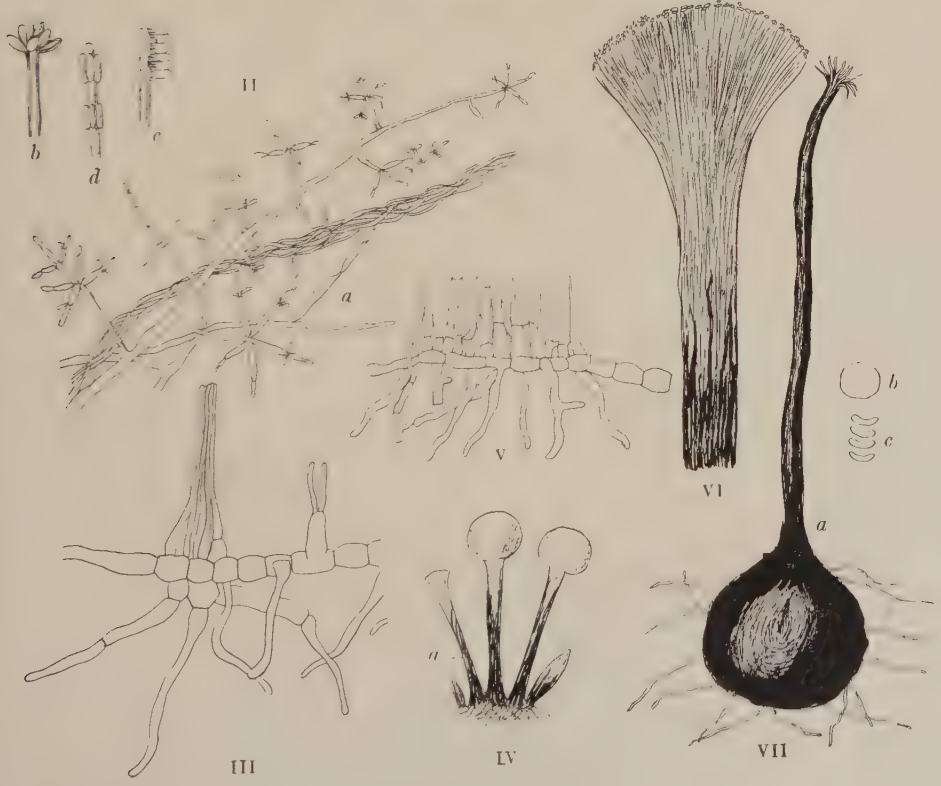
Fig. 4. A group of Graphia. ×25.

Fig. 5. Base of a young Graphium.

Fig. 6. Tip of Graphium before production of the drop. ×150.

Fig. 7 (*a*) The perithecium. ×65.
(*b*) Wall of ascus. ×650.
(*c*) Ascospores. ×500.


I


b
d
c
II
a
V
VI
b
c
a
III
IV
a
VII

# THE NATIONAL COLLECTION OF TYPE CULTURES.

*By R. St John Brooks, M.D., D.P.H., M.A.*

The inception of the National Collection of Type Cultures was due to the initiative of the Medical Research Committee (now the Medical Research Council), who had long had in view the formation of a collection where biologists in general and bacteriologists in particular might obtain authentic strains of bacteria, protozoa, etc., for use in scientific work. The need of an available supply of this kind had long been felt in many directions and particularly in medical research work, for the study of principles and methods in bacteriological technique and for the systematic classification of bacteria, protozoa, etc., in their various species and strains.

In the past the needs of workers in this respect had never been fully met. In this country the Lister Institute of Preventive Medicine had for many years assisted bacteriologists both at home and abroad, so far as the resources of its own private collection permitted, but British workers had been dependent in great part upon the courtesy of scientific colleagues or upon the collections of Institutes in other countries. Before the war the collection of the Pasteur Institute in Paris, maintained by M. Binot, was very helpful to workers here. A collection of type cultures was formerly maintained on a commerical basis by Král at Prague and this was subsequently transferred to the Sero-physiological Institute of Vienna. In America, the Museum of Natural History in New York has maintained a Culture Bureau during the last nine years and it is believed that the activities of the Bureau have been of the greatest benefit to workers there.

Early last year the Medical Research Council were able, by the courtesy of the Governing Body of the Lister Institute, to make arrangements to maintain a National Collection of Type Cultures at the Institute, where all the necessary facilities had been provided. The scheme is under the general direction, on behalf of the Council, of Prof. J. C. G. Ledingham, a member of the Staff of the Lister Institute, the writer being appointed by the Council to be Curator of the Collection with Miss M. Rhodes as Assistant Curator.

Since the formation of the Collection in January 1921 some twelve hundred strains of micro-organisms of medical, veterinary and economic importance have been incorporated in the collection and cultures have been distributed to workers at home and

abroad at the rate of about two thousand per annum. This number is expected to show considerable increase in the not distant future. A catalogue giving all the strains conserved up to date is at present in the press and is expected to be available for distribution very shortly. The Staff are prepared to give assistance in the identification and classification of strains sent in by correspondents.

### *Mycological Collection.*

During the early part of the current year it was proposed to extend the scope of the National Collection by including representative fungi derived from various sources. As was the case with bacteria, so also the need of a Mycological Collection had long been felt. To some extent the Centraalbureau voor Schimmelcultures, Amsterdam (now at Baarn), had been found useful by British and Imperial botanists, but it was the general opinion that a collection of fungi in this country was very necessary for the co-ordination of research. No other Institution contemplated the formation of such a collection at that time and the National Collection was glad to be in a position to offer its services to Mycologists. In order to insure that this side of the collection might be made of the most value, the British Mycological Society were asked to appoint a fully representative standing committee to advise and assist in all questions appertaining to fungi. The following members of the Society were appointed:

| | |
|---|---|
| Prof. V. H. Blackman | Dr E. J. Butler (*Chairman*) |
| Mr W. B. Brierley | Mr A. D. Cotton |
| Mr F. T. Brooks | Mr J. Ramsbottom |
| Dr R. St John Brooks | Miss E. M. Wakefield. |

The scope of the Mycological Collection includes the collection and maintenance of cultures of fungi of importance in phytopathology, medicine, veterinary science, technology and soil biology, types useful for teaching purposes and any rare or interesting species. At present it is not possible to cope with the innumerable strains of common fungi and only room can be found for those forms with some published distinguishing name or symbol.

It is found necessary at present to restrict the collection to fully identified species of fungi and in sending these it should be stated by whom they were named, and also whether a special medium is required for their growth, as only a few standard media are in general use in the collection. It must naturally be left to the discretion of the Curator and the Advisory Committee to decide whether given cultures are of

sufficient importance to be maintained in the collection. Cultures will be supplied on demand, so far as possible, to workers at home and abroad and, as a rule, a small charge will be made to defray the cost of media and postage.

Annual lists of the fungi in the collection will be published in the Transactions of the British Mycological Society. A set of type slides of fungi will be kept in the Botanical Department of the British Museum (Natural History) in addition to a working set at the Lister Institute.

## NOTES ON MALAYAN MYCETOZOA.

*By A. R. Sanderson, F.L.S.*

The part of the Malayan Peninsula dealt with in the present paper lies between North Latitude 1° and 6° and East Longitude 100° and 104°. It is a long narrow spit of land pointing south. An irregular ridge of mountains extends from north to south of the peninsula, some of the peaks rise to over 6000 ft., but all are clothed to the summit with tropical forest.

The climate throughout the year is warm, moist and equable; the rainfall is abundant and not confined to any one season (see notes on rainfall below), the tropical vegetation is luxuriant.

Apart from gatherings by Haviland, Burkill, Chipp and Sappan, very few records for Mycetozoa in Malaya existed prior to 1918. Although a considerable number have been added since, the present paper cannot claim to be more than a preliminary report, the observations as noted being records made at odd moments and at more or less irregular intervals; they merely indicate what a fruitful field awaits the enthusiast who has ample time at his disposal to investigate the distribution in the tropics not only of Mycetozoa but of fungi and cryptogams in general.

Before proceeding to deal with the various species of Malayan Mycetozoa and their habitats, it is advisable to consider the peculiar conditions prevailing in Malaya, more particularly along the western half, that is over all of the peninsula bounded on the east by the natural barrier of mountains.

Large tracts of tropical virgin forest have been cut down, one might almost say ruthlessly destroyed, in order to clear land chiefly for the purpose of planting rubber trees, *Hevea brasiliensis*. It is likely that further portions of forest will share the same fate in the near future, especially in the states of Pahang and Kelantan which lie in the eastern half of the peninsula. Probably over one and a half million acres of the land which

has been cleared of jungle is already planted with this one species *Hevea brasiliensis*. The rubber plantations must therefore be regarded for the present purpose as forming a more or less continuous forest. The ground beneath the trees is kept fairly clean weeded, a very different state of things from the natural forest with its inextricable tangle of low growing plants and creepers. While the trunks of the native trees usually carry a rich and varied epiphytic vegetation, those of the rubber trees are comparatively clean. There are also extensive coconut plantations, and here we have another case of large areas given up to a single species of tree. Belts of forest reserve to some extent interrupt the continuity of the plantations but they are for the most part narrow, and in the western portion of the peninsula rarely exceed a few miles in depth.

When searching for Mycetozoa, rubber and coconut trees received special attention, partly because they were more easily examined, and also because they were most productive. I think it may be safely assumed that the Mycetozoa occurring on these trees have spread there from the jungle from the fact that a large proportion of the species which have been found on Hevea and coconut are also recorded on jungle timber. Hevea is a soft timber and yields a never-ending supply of decaying wood in the form of logs, stumps and boughs which are the result of thinning out or cutting down because of disease; they form a very favourable nursery for Mycetozoa. Thinned out timber, and diseased logs and stumps of Hevea are usually destroyed by burning in prepared pits (fire-pits) or are taken away and stacked for use as fuel; the half-burnt and stacked material has many times proved most productive of Mycetozoa.

The virgin forest consists of an intimate mixture of hard, medium and soft wooded trees, the medium and soft woods probably predominating except in certain districts. Conifers are practically limited to a single species, the Dammar (*Agathis alba* Lam.), which occurs only sparingly. There is therefore no area of jungle which as regards conifers is comparable to a pine forest in temperate regions. The nearest approach to a natural forest consisting of only few species is to be found perhaps in the mangrove swamps.

The hard timber usually decays extremely slowly and from it both fungi and Mycetozoa are usually absent or occur only sparingly. This apparent scarcity is probably due to the fact that the succession of saprophytes is spread over a much longer period owing to the slower rate of decay. On two hard-wood trees, however—Merbau (*Intsia Bakeri* Prain) and Rassa (*Shorea barbata* Brandis)—I have gathered small colonies of *Physarum nucleatum* and *P. auriscalpium* not longer than three weeks after

felling. The method of felling is to cut into one side 3 to 4 ft. from the ground with an axe, the tree falling over towards the cut side. On the top of the stump a brush of torn wood fibres is usually left; on these the sporangia of Mycetozoa are found, and also in the deep cracks in the wood which are constantly damp since the stumps are in dense forest. The soft woods which decay rapidly provide the most suitable habitats for fungi and Mycetozoa generally.

So far as my experience goes, dead leaves, fallen twigs and dead herbaceous plants have been singularly unproductive of Mycetozoa, but a few striking instances have been noted of their occurring amongst rank decaying vegetation even in the gloomy depths of heavy jungle. In some cases they have been observed on fallen leaves before decay has advanced very far; it was then difficult to determine whether the plasmodia actually developed on the leaf, or crept to that position from other material and continued to feed there, or merely passed on to the leaves to fruit. As even living leaves in the tropical forests often carry a micro-flora consisting of algae, mosses, hepatics and lichens, it is quite possible there may be sufficient material on nearly fresh leaves to feed plasmodia. When once leaf-decay sets in a host of fungi and bacteria quickly appear and complete the process of destruction.

Although the decaying leaves and vegetable débris on the ground have not so far proved productive, yet similar material collected in the fork of a branch or about dead leaf-bases still attached to the tree may often yield quite a large number of species.

The trunks of living trees covered with a rich epiphytic flora of ferns, mosses and lichens, provide Mycetozoa with a suitable arboreal habitat. The arboreal species almost invariably occur along the lines of the natural rain track down the trunk, the direction of the lines being determined by the branching of the trunks or in the case of the palms by the arrangement of the leaf-bases. According to my observations the leaf-bases of wild bananas and some aroids have never provided a single species.

From the very equable temperature and from the rainfall being distributed throughout the year, it is not surprising that many species of Mycetozoa seem to have no definite season for making their appearance, and sclerotium, the resting stage of plasmodium, is rarely met with, at least in the district of Petaling.

So far as my limited experience goes, Mycetozoa require very careful search in the virgin forest, the results being as a rule disappointing. This apparent scarcity, for I believe it is only apparent, may be due largely to the wealth of insect life, which

although not always evident from a superficial survey, is at once revealed when one looks more closely. Ants of many species abound almost everywhere, and they devour the sporangia of some Mycetozoa eagerly. The larvae of various coleoptera, lepidoptera and diptera also do their share; as a rule their attentions are directed to the immature or freshly matured sporangia; for some reason the stalks are frequently left. Besides these foes they are subject to attack by various small beetles, but probably ants do most damage. I have frequently observed ants devouring immature sporangia of *Arcyria denudata* and *Hemitrichia clavata*, while a small tiger beetle has apparently acquired a taste for *Perichaena vermicularis*. Fungi and bacteria seem to be equally effective in causing the rapid destruction of mature sporangia and heavy rain washes them away. Hence it follows that unless one is fortunate enough to see a colony almost immediately after it has matured the whole may quickly disappear.

Almost the first point that one notes with regard to tropical Mycetozoa is the absence or rarity of certain species which are exceedingly common in temperate climates, such for example as *Physarum nutans* and *Trichia varia*. The question of temperature is suggested as a possible reason for this as I believe that in temperate regions the majority of species reach maturity during the cooler periods of the autumn months and early spring. The abundance of other species in the tropics which are rare elsewhere, is equally noteworthy.

### *Collecting and preserving specimens.*

A few notes on preserving the specimens of Mycetozoa in the tropics may not be out of place.

In the field I find lightly wrapping each gathering in a separate piece of paper on which is written any note which may be useful afterwards is all that is necessary. On returning to the house these are placed at once in a desiccator over benzine fumes and left for half to one hour. I found this a very necessary precaution to kill the numerous small insects, larvae, etc., which otherwise might, and on occasion did, consume the sporangia. Each specimen is then transferred to a match box or larger box as required, and is labelled with date, locality and the material on which the sporangia formed.

The next thing is to get the gathering dried as quickly as possible, and this I usually did by exposing it to the sun on a small, low bench, the legs of which stood in cups containing crude creosote. If the specimen is on wood this had been soaked previously with the same material; this ensures against insect attack while drying.

Once thoroughly dried the collection is put away in large tin boxes (usually biscuit boxes) with a liberal supply of naphthalene balls. Even with these precautions I have lost some specimens, eaten by insects. The climate is so damp that I find it necessary to expose to the sun at intervals, always taking precautions to keep off small insects. In some cases I have had to expose sporangia to benzine fumes a second and third time. At first I tried chloroform instead of benzine, but I believe this caused some of the specimens to fade a little.

### *List of Mycetozoa found in South Malaya.*

*Ceratiomyxa fruticulosa* Macbr. The species occurs commonly both in the lowlands and up to 2700 ft., sometimes in very large colonies. Most frequently it appears on logs which have reached an advanced state of decay, but once I saw a fine colony on a Ficus stump in which decay had not progressed far.

*C. fruticulosa* var. *flexuosa* Lister. The variety is almost as frequent as the species. Both are widely distributed.

*Badhamia orbiculata* Rex. This species occurs very frequently on living Hevea trees, sometimes in large colonies; it is almost as common on the trunks of coconut palms, and in both cases is always to be found along a water trickle. I have searched in vain for it on other trees in the jungle and have rarely seen it on fallen logs of Hevea or on decayed coconut stems on the ground. On several occasions it has occurred in large masses on living coconut palms up to a height of over 15 ft. In dry weather when dehiscence of sporangia takes place the white rod-like projections of the capillitium from the sporangium wall inwards are an unmistakable feature. About the middle of December 1920, while visiting Kuala Lumpur, I noticed that six coconut palms appeared as though sprinkled with white-wash on one side from about 20 ft. to the base of the trees; closer examination showed this to be entirely due to *B. orbiculata* —a most striking appearance.

*Badhamia affinis* Rost. This is apparently a rare species in Malaya.

*Physarum melleum* Mass. Very extensive colonies of this species occur fairly frequently, sometimes on decaying leaves and twigs, at other times on dead timber, especially of Hevea; on two occasions I found it covering the fructifications of *Ustulina zonata*, and once on *Fomes lignosus*. It appears to be one of the seasonal forms, since for several months at a time no trace of it appears. The colour of the plasmodium is somewhat variable, sometimes being, as Petch described it, a watery yellow, and at other times a very bright opaque yellow. Later observations of the plasmodium showed that it increased in

depth of colour and in opacity just before the formation of sporangia. One doubtful gathering turned out to be this species with lime-knots yellower than typical.

*Physarum columbinum* (Berk. and Curt.) Sturgis (syn. *P. compactum* Lister). This I have gathered twice, once near the base of an old jungle stump in Johore, a part of the colony being on the soil. The stump was one of many left after felling in the course of clearing. Most of the sporangia had either been eaten or knocked off. On the second occasion I found an extremely large colony consisting of many thousands of sporangia; they are dull grey in colour and deeply umbilicate above, so that I at first regarded them as *Physarum javanicum* Racib. The stalks are often very short and are dull yellow in colour; the enclosed lime is not in granules as usual, but is compacted into large crystalline nodules. The plasmodium, a large anastomosing network of somewhat thick, dirty grey opaque veins, resembled that of *Physarum nutans* Pers. This was spread over the base of an old Ficus stump and on the damp earth near the edge of the jungle.

*P. viride* Pers. *P. viride* var. *incanum* Lister.
*P. viride* var. *aurantium* Lister. *P. viride* var. *rigidum* Lister.

This species with its varieties appears to be the commonest representative of the genus in tropical Malaya. The type is I think less common than the varieties; var. *aurantium* is very frequent on the leaf-bases of coconut palms, generally on the inner surfaces; var. *incanum* occurs in similar situations to the preceding, and much more rarely on fallen leaf-bases of some other palms; var. *rigidum* is by far the commonest form, immense colonies appearing with great regularity, and very frequently on *Schizophyllum commune* which is a frequent saprophyte on Hevea and other timbers. Twice I have seen small developments of this variety on species of polypores (see p. 299).

*P. auriscalpium* Cooke. This species occurs, but not commonly, on the leaf-bases of palms, usually while the leaf-stalks still remain attached to the trunk. Several times I found small colonies on bunches of dead leaves of *Passiflora* sp. and *Gardenia* sp. which were either suspended from or caught in the fork of a tree. Once a colony appeared on a stripped surface trunk of Hevea. The cortex had been removed from a portion of the stem as an experiment, leaving only the cambium and a few layers of cells covering the woody tissue. The regenerated cortex was killed by an inoculation with a fungus and the resulting diseased tissue yielded a fine colony of *Physarum auriscalpium* three weeks after stripping. I failed to notice the plasmodium. On several occasions large colonies of this species

have appeared on the tapped surfaces of Hevea attacked by *Sphaeronema fimbriatum* ("Mouldy Rot of the Tapped Surface").

*P. nucleatum* Rex. This also is moderately frequent on palms in similar situations to *P. auriscalpium*; I have also found both species on torn wood-fibres of *Intsia Bakeri* and *Shorea barbata* about three weeks after the trees were felled. Unless one is fortunate enough to see it before or soon after the sporangia begin to dehisce most of the minute central balls of calcareous matter will have fallen out.

*P. reniforme* Lister. This occurs on Hevea logs, and on a few occasions I have met with it 5 to 7 ft. high on the living stems. It has appeared twice on Hevea just below a diseased portion of the cortex where fluid was exuding from holes made by boring beetles (a species of Xyleborus); the colony of sporangia followed the line of the stream of fluid; once it appeared on the dead cortex of Hevea attacked by *Ustulina zonata*.

Two forms of the species occur; one with long-stalked hammer-headed sporangia, like the type from Ceylon, with rough spores, 12–14 $\mu$ diameter; the other with smaller and less rough spores measuring 10–12 $\mu$, and with the sporangia in close clusters; the latter form is fairly frequent.

*P. pusillum* Lister. One gathering only.

*P. virescens* Ditm. One small colony from jungle, in Johore.

*P. lateritium* Morgan. This species occurred continuously on soft-wood jungle logs during July, August and September 1920. The plasmodium was a dirty chocolate grey and persisted for some considerable time as very thick anastomosing veins. The young sporangia were brilliant yellow, rapidly darkening to a yellow-brown with age.

*Fuligo septica* Gmelin. Although I have several times gathered this species both in Malaya and Ceylon it is apparently not very common there. On five occasions I have found it on jungle logs and several times on Hevea logs, but the aethalia were always somewhat small, never exceeding 5 cm. across. The lime contents seemed greater than is usual with the English specimens I have examined. One large specimen 10 cm. diameter was found on a Nibung palm (*Oncosperma filamentosa*) stump near Petaling. Very frequently the aethalia are reduced to a mere shell, the spores having been consumed by small beetles.

*F. cinerea* Morgan. This species occurred frequently on stacked Hevea and jungle timber at Petaling during the early part of 1921. As with the preceding, small beetles frequently attack the spores.

*Erionema aureum* Penz. Several times I have been fortunate enough to find this species. Once it occurred on a jungle log in an advanced stage of decay which had been exposed during

planting operations. Three gatherings were made in Johore, two being on much decayed logs and stumps of Kumpas (*Koompassia malaccensis* Maingay). One of these logs was almost covered with an immense colony of *Cribraria intricata*. The third gathering of Erionema, a very large one, was on the upper surface of a large polypore. When I found this I had no box to place it in, so I carefully moved it, anticipating picking it up later; when two days later I returned, there had been several violent rain storms and little trace of the Erionema was left on the fungus. A rich chrome yellow plasmodium which was issuing from the cut end of a very old hard-wood stump developed ten days later into small colonies of this species. The bright colour does not agree with the "colourless or pale yellow" plasmodium described in Lister's monograph.

*Trichamphora pezizoides* Jungh. This is one of the common species found on Hevea logs both in Ceylon and in Malaya. It occurs also on other wood, especially on felled timber which has been stacked for some time. Colonies of large size are frequent. Early in December 1920 I found this species on an old Hevea log which I had kept under observation for some months, and from which I had collected the mature sporangia a fortnight before. The log, which was lying on the edge of the jungle, was almost covered with a remarkable development of the dirty grey plasmodium. In many places the fine network of veins had given place to a complete sheet, and the main veins were in places half-an-inch in diameter. Altogether, the plasmodium, which had spread over various adjacent species of the higher fungi, including *Daldinea* sp., *Tremellina* sp., *Ustulina zonata* and *Schizophyllum commune*, must have covered many square feet. When crawling on the fungi the plasmodium was apparently much more watery and lighter in colour*.

*Physarella oblonga* Morgan. So far as my experience goes this is one of, if not the commonest species in tropical Malaya, more especially in the lowlands below 500 ft. One can be almost certain of a gathering at any time of the year by examining a few decaying logs of *Hevea brasiliensis*. Very large colonies of typical sporangia are frequent, and occasionally confluent forms occur. The plasmodium resembles that of *Badhamia utricularis* in colour and usually leaves very definite tracings of brown residual matter. When the sporangia dehisce the beautiful rich yellow columella is a marked feature and readily distinguishes it. For some reason the various insects which quickly destroy many species leave this one severely alone.

* The appearance of the plasmodium of *Physarum viride* var. *rigidum* changes in a similar manner when developing on some species of fungi, and the plasmodium of *Badhamia utricularis* reacts similarly when cultivated on the common mushroom.

*Cienkowskia reticulata* Rost. I had three gatherings of this species. One was a very fine colony spread over the bases of palm leaves lying on the ground and over some leaflets of Hevea. The portions which were dehiscing showed the deep orange base of the sporangium lying close to the substratum, as well as the delicate pale yellow capillitium and dark spores. This species is unmistakable after being once seen in the field. A second specimen, consisting of two small colonies, was found also on palm; a third small growth was on a somewhat decayed jungle log.

*Craterium minutum* Fries. Only once have I gathered a very meagre colony of this species which is so common in England. It was on some leaves and débris on the edge of a jungle swamp where many leaves and twigs showed tracks of plasmodium.

*Diderma arboreum* G. Lister and Petch. This species occurs on the living trunks of coconut palms and Hevea but apparently is not very common. I have found fairly large colonies on a decayed log in the jungle, and once I noticed it on a living Hevea tree, immediately after felling, at a height of about 30 ft.

*D. effusum* Morg. This species has been observed on dead leaves, but is apparently not common.

*D. hemisphericum* Hornem. This occurs in similar situations to the preceding; I have once seen it on bases of coconut leaves.

*Diachea leucopoda* Rost. I have twice found very extensive growths of this species, once on decaying Hevea leaves and twigs, and once on dead leaves of Gardenias and Crotons.

*Didymium Clavus* Rost. This is very common in small widely scattered colonies on decaying leaves of many kinds.

*D. nigripes* Fr. One gathering only.

*Stemonitis fusca* Roth. This species is very frequent on rotting jungle logs, especially those in drier situations, and on the under surface of Hevea tap roots which have been dug out because of disease. It also occurs very commonly in fire-pits on half-burnt Hevea and on many other logs left on the ground after a "burn off," i.e. clearing the land of jungle.

*S. splendens* Rost. Although not nearly so frequent as *S. fusca* this is fairly common, especially on Hevea logs, and is one of the earliest to appear; the sporangia are frequently very long and densely fasciculate.

*S. ferruginea* Ehrenb. This is almost as common as *S. fusca* and occurs in similar situations. Usually the development takes place in a series of somewhat scattered small groups.

*Comatricha laxa* Rost. This is represented by two small gatherings.

*C. pulchella* Rost. This species has occurred twice, once on leaves of Gardenia and Thunbergia in Selangar, and the second

time in great profusion on various dead leaves but especially on Rassa (*Shorea barbata*) in Johore. Several square feet of material were more or less covered with the sporangia which in places were densely aggregated. In the first gathering the sporangia vary in the denseness of the capillitium, some having an extremely lax capillitium, while others have a denser intermediate system of threads and something of an imperfect surface net on the lower half.

*C. typhoides* Rost. This seems to be by no means a common species, and the colonies I have seen have usually been small. One exceptionally large growth occurred however on a very much decayed log of "Jak" (*Artocarpus integrifolia*) in an abandoned garden.

*C. longa* Peck. Of the species of Comatricha this is one of the commonest, especially on Hevea logs which are in an advanced stage of decay. The long black sporangia densely aggregated and drooping are very characteristic. It frequently appears also on the soil around rotting stumps and on several occasions I have seen it on half-burnt Hevea logs in fire-pits. On cutting away a freshly matured colony the wood beneath frequently shows rich bright almost gamboge yellow coloration due to the plasmodium; this occasionally extends to a depth of one-eighth of an inch.

*C. irregularis* Rex? One doubtful gathering of this species was made varying somewhat from the typical form. Miss Lister describes the capillitium as stouter and darker at the extremities than any specimen previously seen, the columella being more rigid and the spores bigger and more spinose. The specimen is in a damaged condition.

*Lamproderma arcyrionema* Rost. This is the only representative of the genus recorded from Malaya. It occurred only on three occasions, each time in large colonies. Once it had developed on leaf-bases (outsides) of coconuts.

*Cribraria violacea* Rex. I have found this on coconut palms many times; it was plentiful on the insides of decaying leaf bases where there is much decaying vegetable matter and abundant moisture. It may be quite common in such situations but it is difficult to see. Once it occurred on "Nibung" palm (*Oncosperma filamentosa*).

*C. intricata* Schrad. This species occurs on coconut palms fairly frequently and on two occasions in Johore I have seen very large colonies each numbering thousands of sporangia crowded together on old Kumpas logs (*Koompassia malaccensis*). The dark lead coloured plasmodium was observed in the decayed timber.

*Dictydium cancellatum* Macbr. This very common species

occurs in immense colonies, but is seldom in perfect condition, as various insects and their larvae eat the sporangia.

*Tubifera ferruginosa* Gmel. One gathering only.

*T. stipitata* Macbr. My first gathering of this was from an old Ficus stump, the next from the bath room floor; several times I have found it on Hevea logs. It is apparently much more common in Malaya than the preceding species, frequently occurring in great abundance; on one stump I collected 50 aethalia: twice I have found it on Kumpas logs.

*Alwisia Bombarda* Berk. & Br. I have found this on three occasions on decayed jungle timber where a clearing had recently been made. One colony was small and not in good condition; the second, a very large one, was collected in Johore on "merbau" (*Intsia Bakeri* Prain). Another development was seen covering the end of a moss-covered rotten jungle log, and this seems its favourite habitat. It has not been my good fortune to see the plasmodium of this species. Usually the sporangia bear evidence of being partly eaten by insects. In suitable habitats it is probably not uncommon.

*Dictydiaethalium plumbeum* Rost. This species has been gathered on Hevea logs, jungle logs, and on dead leaves. One aethalium was over 4 cm. diameter.

*Reticularia Lycoperdon* Bull. This is not uncommon on Hevea logs, but the aethalia are small, rarely exceeding 3 to 4 cm. in diameter and it is difficult to find a perfect specimen. As in some English specimens, dipterous larvae feed on the immature aethalia.

*Lycogala epidendrum* Fries. Scanty colonies of small aethalia are fairly frequent on Hevea logs, where on one occasion I found a typical colony of scores of aethalia crowded together. I have also seen it on Nibung palm.

The genus Trichia in my experience is not commonly represented in Malaya. Such species as *Trichia varia* Pers., *T. decipiens* Pers. and *T. Botrytis* Pers., all of which are exceedingly abundant in Britain and throughout the temperate regions, I have not yet seen in these parts, even when searching at 2700 ft. altitude. I have only gathered two species of the genus, and these by no means frequently.

*T. affinis* de Bary. This occurs sparingly on decayed jungle logs and to a limited extent on Hevea and on dead leaves.

*T. persimilis* Karst. Like the preceding this is far from common; it occurs in similar situations.

*Hemitrichia Vesparium* Macbr. I met with this species once only in Malaya, on old rubber wood. The gathering was typical but small and showed signs of insect attack.

*H. clavata* Rost. This occurs much more frequently than the

preceding, the commonest habitat being the leaf-bases of coconut palms. I have also seen it often as an arboreal species on living Hevea and on several palms in the jungle, but the best developments are on Hevea logs. It is very liable to be eaten by insects.

*H. Serpula* Rost. This also occurs on the leaf-bases of coconut palms both on the inner surface and on the persistent fibrous decayed sheaths. In such situations it is very common and can be found all the year round. Less frequently it appears on Hevea, and on one occasion I saw a small isolated specimen on a decayed jungle log.

*Arcyria ferruginea* Sauter. The usual habitat of this species is the remains of Hevea logs and stumps in fire-pits, and on heaps of diseased lateral roots of Hevea; in both situations large colonies are fairly frequent. Occasionally it appears on fallen decaying branches of Hevea.

*A. cinerea* Pers. This is much more common than the preceding species. Large growths have appeared on the under surfaces of diseased Hevea tap roots which have been pulled up. It occurs sparingly on trunks of living coconut palms and on living Hevea trunks, the sporangia in such situations usually being very much scattered. A scattered form also occurs on living jungle trees. The "digitate" or clustered form is especially characteristic of developments of palm stems.

*A. denudata* Wettst. This species is very common on fuel heaps of split timber and on small diseased roots of Hevea, especially those affected with *Sphaerostilbe repens*. I once gathered it on dead leaves of Gardenia, associated with *Comatricha pulchella*. It is very frequent on half-burnt logs and stumps in fire-pits.

*A. nutans* Grev. Though not so abundant as the preceding species it is fairly frequent, and varies somewhat in colour from a decided buff to a browner tint somewhat resembling *Arcyria ferruginea* in older specimens.

*A. virescens* G. Lister. This striking species was recently described by Miss G. Lister (see Journal of Botany, LIX. 252, Sept. 1921). The green spores at first led me to believe this was a form of *A. glauca*, but it differs from that species in the long dark stalks and stouter capillitium marked with groups of prominent bars. Much-faded specimens, from which most of the spores had disappeared, have several times been passed as over-faded *Arcyria nutans*. The species is not uncommon in Johore where it occurs on jungle logs, sometimes in colonies of considerable size. It has several times been found in Selangor on stacked fuel timber of various kinds.

*A. insignis* Kalchbr. and Cooke. I once found this species

on the unusual habitat of dead leaves. The small scattered sporangia varied from 0·15 to 0·7 mm. in total height. Miss Lister who examined the specimen remarked of this, "It seems to correspond in character with the leaf-haunting form of *A. cinerea*, i.e. it bears the same relation to the usual wood form that the leaf form of *A. cinerea* does to the typical form on wood."

*Perichaena vermicularis* Rost. This occurs frequently, especially as an arboreal form on Hevea and palms. I once gathered some fine sporangia from a newly felled Hevea tree; they occurred quite 40 ft. up the stem and were associated with scattered groups of *Badhamia orbiculata*. Diseased Hevea trees are usually attacked by species of boring beetles. From the punctures 2 to 6 ft. from the ground a liquid in the form of bubbles of fermenting sap exudes and flows in a thin stream down the trunk; the track of these streams appears to be particularly favourable for the development of this Perichaena. One specimen was gathered from a jungle log at an altitude of over 2000 ft. in Negri Sembilan.

*P. depressa* Libert. This is fairly frequent, the sporangia occurring in the cracks of bark.

*P. chrysosperma* Lister. Three gatherings of this species have been made, two being on *Hevea brasiliensis*, and one on Nibung palm.

*Margarita metallica* Lister. I have found this sparingly among the moss and algae on tree trunks in situations similar to those frequented by *Badhamia orbiculata*. Coconut palms appear to be the trees most favoured. A somewhat abnormal specimen was found on a dark felt of algae on coconut wood; it consisted of long slender lilac-pink plasmodiocarps with rather stout capillitium threads.

### *Distribution of rainfall in Malaya.*

The rainfall records as under for three successive years may be taken as fairly typical. The records "A," "B," and "C" are for districts near to the mountains or approaching the foot-hills.

A. Northern Johore:

| | | |
|---|---|---|
| 1918 | 121·3 | inches (total for year) |
| 1919 | 97·5 | ,, |
| 1920 | 103·7 | ,, |

B. Central Negri Sembilan, near Seremban:

| | | |
|---|---|---|
| 1918 | 85·1 | inches |
| 1919 | 93·8 | ,, |
| 1920 | 101·3 | ,, |

C. Northern Selangor, near Kuala Kubu:

| | | |
|---|---|---|
| 1918 | 108·5 | inches |
| 1919 | 85·7 | ,, |
| 1920 | 92·0 | ,, |

The rainfall chart appended is for the Jeram district of Selangor. This is fairly typical for the drier low-lying plains near the western coast.

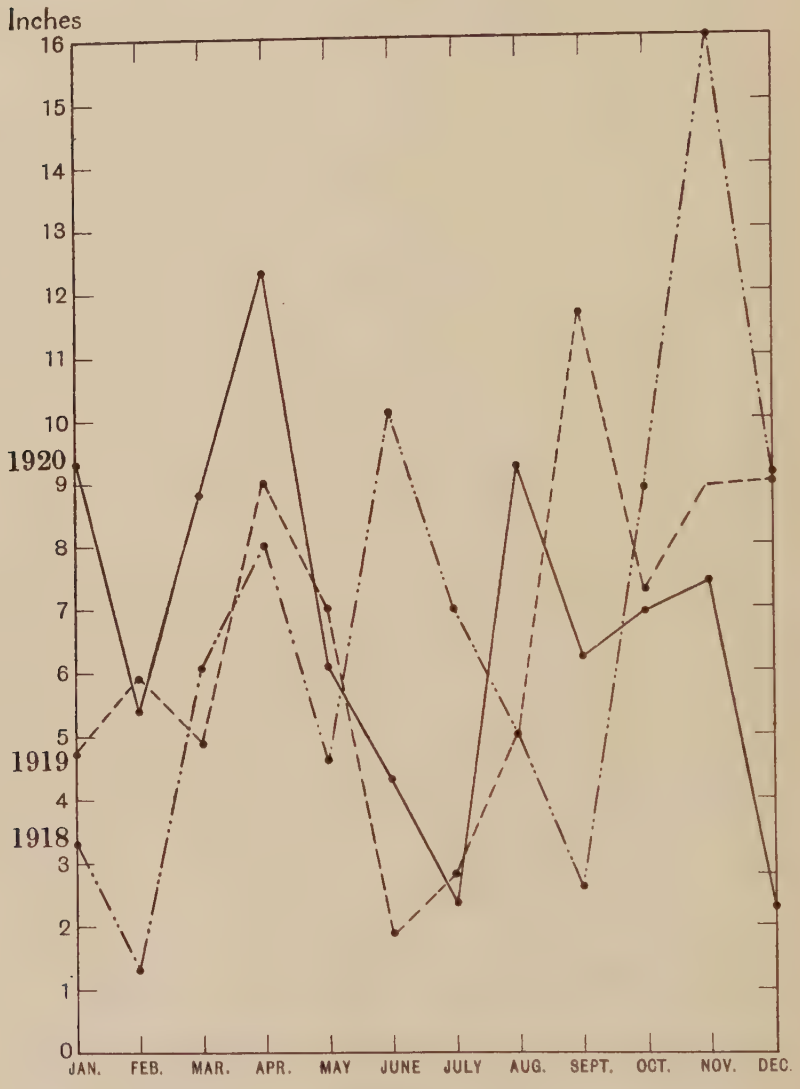



Fig. 1.

Rainfall chart for three years, 1918–20. Jeram District, Selangor.
Total rainfall in inches: 1918 = 82·5, 1919 = 78·7, 1920 = 80·7

*Table showing the occurrence of species throughout the year in South Malaya.*

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Ceratiomyxa fruticulosa Macbr. ... ... | × | × | × | × | | × | × | | × | × | × | × |
| ,, ,, var. flexuosa ... | | × | | × | | | × | × | | × | | |
| Badhamia orbiculata Rex ... ... ... | | × | | × | | | × | | | × | × | × |
| ,, affinis Rost. ... ... ... | | | | | | | | | | | × | |
| Physarum columbinum (Berk. & Curt.) Sturgis | | | | × | | | | | | | × | |
| ,, psittacinum v. fulvum Lister ... | | | | | | | | × | | | | |
| ,, viride Pers. ... ... ... | × | × | × | × | | | | × | × | × | × | × |
| ,, ,, var. aurantium Lister ... | | | | | | | | | × | | × | |
| ,, ,, ,, incanum Lister ... | | | | | | | | | | × | | |
| ,, ,, ,, rigidum Lister ... | × | × | × | × | | × | | × | × | × | | × |
| ,, melleum Mass. ... ... ... | | | | × | | | × | | | × | × | × |
| ,, auriscalpium Cooke ... ... | × | | | × | | | | × | | | × | |
| ,, nucleatum Rex ... ... | | × | | | × | | | × | | | × | |
| ,, compressum Alb. & Schw. ... | | | | | | | | | | | | |
| ,, nutans Pers. ... ... ... | × | | | | | | | | | | | |
| ,, reniforme Lister ... ... | × | × | | × | | | × | × | | | | × |
| ,, virescens Ditm.... ... ... | × | | | | | | | | | | | |
| ,, pusillum Lister ... ... | | | | | | | | | | | × | |
| ,, lateritium Morgan ... ... | | × | | | | | | | | | | |
| Fuligo septica Gmelin ... ... ... | | | × | × | | | | × | | | | × |
| ,, cinerea Morgan ... ... ... | × | × | × | | | | | | | | | |
| Erionema aureum Penz. ... ... ... | | | | × | | | | × | | | × | |
| Trichamphora pezizoides Jungh. ... ... | × | | × | × | | × | | × | | × | | × |
| Physarella oblonga Morgan ... ... | × | × | × | × | × | × | × | × | × | × | × | × |
| Cienkowskia reticulata Rost. ... ... | × | | | | | | × | | | | | × |
| Craterium minutum Fries ... ... ... | | | | | | × | | | | | | |
| Diderma effusum Morgan ... ... ... | | | | | | | | | × | | | |
| ,, arboreum G. Lister & Petch. ... | × | | | | | | | × | × | | | × |
| ,, hemisphericum Hornem. ... | | × | | | × | | | | | | | |
| Diachea leucopoda Rost. ... ... ... | | | | × | × | | | | | | | |
| Didymium Clavus, Rost. ... ... ... | | × | × | × | | × | | | × | × | | |
| ,, nigripes Fries ... ... ... | | | | | | | | | | | × | |
| ,, leoninum Berk. & Br. ... ... | | | | | | | | | | | × | |
| Stemonitis fusca Roth. ... ... ... | × | | | × | | | × | × | | | | × |
| ,, splendens Rost. ... ... | | × | | × | × | | | × | | × | | |
| ,, ferruginea Ehrenb. ... ... | × | × | | × | × | | | | | | | × |
| Comatricha laxa Rost. ... ... ... | | | | | | | | | | | × | |
| ,, pulchella Rost. ... ... | | | | × | | | | | | | × | |
| ,, typhoides Rost. ... ... | | × | | × | | | | | | | × | × |
| ,, longa Peck ... ... ... | × | × | × | × | × | | × | × | | | × | × |
| ,, irregularis Rex? ... ... | | | | | | | | | | × | | |
| Lamproderma arcyrionema Rost.... ... | | | | | | | | | | | × | |
| Cribraria intricata Schrad.... ... ... | | | × | | | × | | | | × | × | |
| ,, var. dictydioides... ... ... | | | | × | | | | × | | | | |
| ,, splendens Schrad. ... ... | | | | | | | | | | | | |
| ,, violacea Rex ... ... ... | | | × | × | × | | | | | × | × | |
| ,, microcarpa Pers.... ... ... | | | | | | × | | × | | | | |
| Dictydium cancellatum Macbr. ... ... | | | × | | | | × | | | | × | |
| Tubifera ferruginosa Gmel. ... ... | | | | × | | | | × | | | | |
| ,, stipitata Macbr. ... ... ... | × | | × | | | | | | | × | × | × |
| Alwisia Bombarda Berk. & Br. ... ... | × | | | × | | × | | × | | × | × | × |
| Dictydiaethalium plumbeum Rost. ... | | × | | × | | | | | | × | | |

*Table showing the occurrence of species throughout the year in South Malaya* (continued).

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lycogala epidendrum Fries ... ... | × | | × | × | | × | | × | × | × | | × |
| Reticularia Lycoperdon Bull. ... ... | × | | × | × | | | | | | × | × | |
| Trichia affinis de Bary ... ... ... | | | | | | | | | | | | × |
| ,, persimilis Karst. ... ... ... | | | | | | | | × | | × | | |
| Hemitrichia Vesparium Macbr. ... ... | × | | | | | | | | | | | |
| ,, clavata Rost. ... ... | × | × | × | × | | × | | × | × | | × | × |
| ,, Serpula Rost. ... ... | × | × | | | | × | × | | | | | |
| Arcyria ferruginea Sauter ... ... ... | × | × | × | × | | | | × | | × | × | × |
| ,, cinerea Pers. ... ... ... | × | × | | × | × | × | | × | | × | × | × |
| ,, denudata Wettst. ... ... ... | × | × | × | × | × | | × | × | | × | × | × |
| ,, nutans Grev. ... ... ... | × | × | × | × | | | × | × | × | | | × |
| ,, virescens G. Lister ... ... | | × | | | | | | | | × | × | |
| ,, Oerstedtii Rost. ... ... ... | | | | | | | | | | | × | |
| ,, insignis Kalchbr. ... ... ... | | | | | | | | | | × | | |
| Perichaena chrysosperma Lister ... ... | | | | × | | | | | × | | × | × |
| ,, depressa Libert ... ... | | × | × | | | | | | | | × | × |
| ,, vermicularis Rost. ... ... ... | × | | | | × | | | | | | × | × |
| ,, corticalis Rost. ... ... | | | | | | | | | | | | |
| Margarita metallica Lister ... ... | | | | | | | | | | | × | |

*Table showing habitats of Malayan Mycetozoa.*

| | Recorder | Hevea logs | Coconut palm | Other palms | Dead jungle logs | Living trees | Leaves |
|---|---|---|---|---|---|---|---|
| Ceratiomyxa fruticulosa ... | S. | × | × | | × | | |
| ,, ,, var. flexuosa | C., S. | × | | | × | | |
| Badhamia orbiculata ... ... | S. | × | × | | | × | |
| ,, affinis ... ... | S. | | | | | × | |
| Physarum columbinum ... ... | S. | | | | × | | |
| ,, psittacinum v. fulvum | S. | × | | | | | |
| ,, viride ... ... | H., S., N., C. | × | × | × | × | | × |
| ,, ,, var. aurantium | H., S. | × | × | × | | × | |
| ,, ,, ,, incanum ... | S. | | × | | | × | |
| ,, ,, ,, rigidum ... | S. | × | | | × | | |
| ,, melleum ... ... | S. | × | | | × | | |
| ,, auriscalpium ... ... | S. | × | × | | | × | |
| ,, nucleatum ... ... | H., B., S. | × | × | | | | × |
| ,, compressum ... ... | N., B., S. | | | | × | | |
| ,, nutans ... ... | B. | | | | | | |
| ,, reniforme ... ... | D., B., S. | × | × | | × | × | |
| ,, virescens ... ... | S. | | | | × | | |
| ,, pusillum ... ... | S. | | | | × | | |
| ,, lateritium ... ... | S. | | | | × | | |
| Fuligo septica ... ... ... | S. | × | | | × | | |
| ,, cinerea ... ... ... | S. | × | | | | | |
| Erionema aureum ... ... | S. | | | | × | | |
| Trichamphora pezizoides ... | B., S. | × | | | × | | |
| Physarella oblonga ... ... | S., N. | × | × | | × | | |
| Cienkowskia reticulata ... ... | S. | | × | × | | | × |

*Table showing habitats of Malayan Mycetozoa* (continued).

| | Recorder | Hevea logs | Coconut palm | Other palms | Dead jungle logs | Living trees | Leaves |
|---|---|---|---|---|---|---|---|
| Craterium minutum ... ... | S. | | | | | | × |
| Diderma effusum... ... ... | S. | | × | | | | × |
| ,, arboreum ... ... | S. | × | × | | | | |
| ,, hemisphericum ... | S. | | | | | | × |
| Diachea leucopoda ... ... | R., B., S. | × | | | | | × |
| Didymium Clavus ... ... | S. | | | | | | × |
| ,, nigripes ... ... | D., S. | | | | | | × |
| ,, leoninum ... ... | B. | | | | | | × |
| Stemonitis fusca ... ... ... | H., S., B. | × | × | | × | | |
| ,, splendens ... ... | S. | × | | | × | | |
| ,, ferruginea ... ... | S. | × | × | × | × | | |
| ,, herbatica ... ... | Sp. | | | | | | |
| Comatricha laxa ... ... ... | S. | × | | | | | |
| ,, pulchella ... ... | B., S. | | | | | | × |
| ,, typhoides ... ... | S. | × | × | | × | | |
| ,, longa ... ... | S., Sp. | × | | | × | | |
| ,, irregularis? ... ... | S. | | | | | | |
| Lamproderma arcyrionema ... | S. | | | | × | | |
| Cribraria intricata ... ... | S. | × | | | × | | |
| ,, var. dictydioides ... | Sp., S. | | | | × | | |
| ,, splendens ... ... | C. | | | | × | | |
| ,, violacea ... ... | S. | | × | × | | | |
| ,, microcarpa ... ... | S. | | × | | × | | |
| Dictydium cancellatum ... ... | S. | × | | | × | | |
| Tubifera ferruginosa ... ... | Sp., S. | × | | | × | | |
| ,, stipitata ... ... | S., Sp. | × | | | × | | |
| Alwisia Bombarda ... ... | S. | | | | × | | |
| Dictydiaethalium plumbeum ... | S | × | | | × | | × |
| Lycogala epidendrum ... ... | R., Sp., S. | × | | | × | | |
| Reticularia Lycoperdon ... ... | S. | × | | | × | | |
| Trichia affinis ... ... ... | S. | × | × | | × | | × |
| ,, persimilis... ... ... | S. | × | × | | × | | × |
| Hemitrichia Vesperium ... ... | S. | | | | × | | |
| ,, clavata ... ... | H., S. | × | × | × | × | | × |
| ,, Serpula ... ... | S. | × | × | | × | | |
| Arcyria ferruginea ... ... | S. | × | | | × | | |
| ,, cinerea ... ... ... | S. | × | × | × | × | × | × |
| ,, denudata ... ... | H., Sp., S. | × | | × | × | | × |
| ,, nutans ... ... ... | C., S. | × | × | | × | | |
| ,, virescens... ... ... | B., S. | | | | × | | |
| ,, Oerstedtii ... ... | C. | | | | | | |
| ,, insignis ... ... ... | S. | | | | | | × |
| Perichaena chrysosperma ... | S. | | | | × | | |
| ,, depressa ... ... | S. | × | | | × | | |
| ,, vermicularis ... | S. | × | × | | | × | × |
| ,, corticalis ... ... | H. | | | | | | |
| Margarita metallica ... ... | S. | × | × | | | × | |

The initials in the Recorder column refer to the following:

H., Dr G. D. Haviland; B., J. H. Burkill; R., H. N. Ridley; C., F. T. Chipp; Sp., Sappan; N., Noor; S., A. R. Sanderson.

I desire to express my thanks to Miss G. Lister, F.L.S., for examining and identifying many of the specimens, for much kindly help in the preparation of the paper and for seeing it through the printer's hands. I am indebted to Mr F. T. Chipp, F.L.S., for reading over part of the original rough notes and for supplying me with information as regards previous records of Malayan Mycetozoa.

# HOMOTHALLISM AND HETEROTHALLISM IN THE GENUS COPRINUS.

*By Irene Mounce, M.A. (British Columbia), Hudson's Bay Company Research Fellow, University of Manitoba.*

## I. Introduction.

In 1918 Mlle Bensaude* brought forward experimental and cytological evidence which appeared to prove that *Coprinus fimetarius* is heterothallic; and in 1919 Hans Kniep†, after making a similar investigation, came to the conclusion that heterothallism is characteristic of *Schizophyllum commune* and of a number of other Hymenomycetes.

In 1921, in a paper published in these Transactions, I recorded that clamp-connections had regularly appeared in mycelia of monosporous origin in *Coprinus sterquilinus*, *C. stercorarius*, *C. lagopus* and *C. niveus*, and that I had therefore come to the conclusion that all these four species are homothallic‡. This paper was sent to England for publication in May 1921. The following autumn, on resuming my investigations, I made a large number of monosporous cultures of *Coprinus lagopus* but found to my surprise that in not a single one of them did any clamp-connections make their appearance. The spore-deposits used for making the cultures described in my previous paper had been destroyed, so that it was unfortunately impossible to investigate them again. The spores in my new cultures, therefore, had a different origin from those previously employed. Suspecting that the strains of the fungus used in my new investigation were heterothallic, I tried the effect of pairing the mycelia. The results of this operation were similar to those

* Mathilde Bensaude, Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes, Nemours, 1918, pp. 1–156.

† Hans Kniep, Über morphologische und physiologische Geschlechtsdifferenzierung, Verhandl. der Physikal.-med. Gesells. zu Wurzburg, 1919, pp. 1–18.

‡ Irene Mounce, Homothallism and the Production of Fruit-bodies by Monosporous Mycelia in the Genus Coprinus, Trans. Brit. Mycolog. Soc. VII, 1921, pp. 198–217.

obtained by Mlle Bensaude and Hans Kniep; certain pairs of mycelia produced clamp-connections in large numbers and others never produced any clamp-connections at all. Moreover, the pairs of mycelia which produced clamp-connections gave rise to perfect fruit-bodies, whilst those pairs which did not produce clamp-connections gave rise only to imperfect fruit-bodies. I therefore came to the conclusion that the strains of *Coprinus lagopus* used for my new investigation were heterothallic. It then seemed highly desirable that I should re-investigate the mycelia of *Coprinus sterquilinus*, *C. stercorarius* and *C. niveus*. I therefore made a new series of cultures for each of these species. With *Coprinus sterquilinus* and *C. stercorarius*, I obtained results exactly similar to those already recorded: clamp-connections appeared regularly on all the mycelia of monosporous origin. My conclusion that these two species are homothallic was therefore confirmed and strengthened. With *Coprinus niveus*, just as with *C. lagopus*, I found that in a series of monosporous cultures not a single mycelium gave rise to clamp-connections but that, on pairing the mycelia, some pairs produced clamp-connections abundantly and some pairs no clamp-connections whatever. I have therefore convinced myself that the strain of *Coprinus niveus* used for my new investigation is heterothallic.

The object of this paper is to bring forward further evidence in support of my previous conclusion that *Coprinus sterquilinus* and *C. stercorarius* are homothallic and to show that *Coprinus lagopus* and *C. niveus* are not always homothallic, as I at first believed, but are often, and perhaps as a rule, heterothallic*.

## II. Criteria of Sex.

This paper is to be regarded as a continuation of the one already published. Here, therefore, it will not be necessary to discuss the criteria for distinguishing a homothallic species of *Coprinus* from a heterothallic one in detail; and it will be sufficient for our present purpose to remind the reader of the following facts. Mlle Bensaude and Hans Kniep, working independently, have shown that the presence of clamp-connections on a mycelium is associated with dicaryons and the conjugate division of the nuclei. Clamp-connections, therefore, are an outward and visible sign that the mycelium on which they arise is in the diploid and not the haploid condition. A species of *Coprinus* producing clamp-connections is *homothallic* if clamp-

* These results were communicated to the Mycological Section of the American Botanical Society at the Toronto meeting of the American Association for the Advancement of Science, December, 1921, in a paper entitled: "Homothallism and Heterothallism in the Genus Coprinus"; but no abstract of this paper has been published.

connections are regularly formed on mycelia of monosporous origin, or if clamp-connections are formed on compound mycelia arising from spores all of which have been derived from a single fruit-body produced from a mycelium of monosporous origin. A species of Coprinus producing clamp-connections is *heterothallic* if clamp-connections are *not* formed on mycelia of monosporous origin but only upon compound mycelia produced by the union of two monosporous mycelia presumably of opposite sex.

Mlle Bensaude, working with *Coprinus fimetarius*, came to the conclusion that, in a heterothallic species, monosporous mycelia are always sterile. However, Kniep has discovered that, in *Schizophyllum commune* and certain other species of Hymenomycetes which are heterothallic, fruit-bodies sometimes appear on mycelia of monosporous origin and of haploid nature, one nucleus finally entering each basidium instead of two. Fruit-body production in a heterothallic species, therefore, is not necessarily bound up with the diploid condition of the mycelium; so that if, on experimenting with a new species, one finds that a fruit-body is produced on a monosporous mycelium, one is not justified by that fact alone in regarding the species as homothallic. Nevertheless, from my own experience with heterothallic strains of *Coprinus lagopus* and *C. niveus*, Mlle Bensaude's experience with *Coprinus fimetarius*, and Kniep's experience with *Schizophyllum commune*, I am of the opinion that, in a heterothallic species, fruiting takes place either not at all or much less readily and less perfectly on a monosporous mycelium than on a compound mycelium formed by the union of two mycelia presumably of opposite sex.

## III. Methods.

The isolation of mycelia of monosporous origin by plating out spores in dung agar was accomplished in the manner already described in my first paper. However, owing to the provision of a new and improved autoclave, the culture medium was sterilised at 15 pounds pressure instead of 7 pounds.

The pairing of mycelia of monosporous origin in the tests for heterothallism was effected as follows. The monosporous mycelia were first grown separately upon dung-agar plates or in wide test-tubes containing horse dung, and then portions of the mycelia were placed in pairs on dung-agar plates. In making an inoculation from two plate cultures, a small piece of mycelium-covered agar about 7–10 mm. square was removed by means of a sterile platinum loop from each of two plates, and these two pieces of agar were placed about 2 cm. apart in the middle of a freshly-poured dung-agar plate. In making an inoculation

from two dung-tubes, the procedure was the same, except for the fact that the two pieces of mycelium-covered dung were removed from the tubes by means of sterilised forceps instead of by a platinum loop.

After portions of two monosporous mycelia had been deposited near one another in an agar plate, the hyphae soon began to grow radially outwards through the agar; and, after a few days, the hyphae of the two mycelia came into contact in a line passing through the centre of the plate, so that fusions could take place between them. At the end of 7–14 days from pairing, the compound mycelium was examined under the high power of the microscope for the presence or absence of clamp-connections.

In the heterothallic strains of *Coprinus lagopus* and of *C. niveus*, a primary (haploid) mycelium differs from a secondary (diploid) mycelium in several ways. (1) A primary mycelium produces oidia in great abundance but a secondary does not. (2) A primary mycelium does not bear clamp-connections, whereas a secondary one does on all the stouter hyphae. (3) The branching of a primary mycelium is relatively irregular, whereas in a secondary mycelium it takes place on all the leading hyphae at a definite angle. (4) It was also noticed that in a primary mycelium the aerial hyphae are more abundant and, therefore, collectively, are more woolly in appearance than in a secondary mycelium. Owing to these differences between a primary and a secondary mycelium, one could usually tell macroscopically, 7–14 days after pairing, whether the sexes of any two paired mycelia were the same or different. Microscopic observation as to the presence or absence of clamp-connections, therefore, usually confirmed what had been surmised by examination with the naked eye.

## IV. *Coprinus sterquilinus*.

The series of monosporous cultures of *Coprinus sterquilinus* of which I gave an account in my first paper has been extended, and now fruit-bodies have been obtained from monosporous mycelia for seven successive generations. When grown under similar conditions, the mycelia of the seventh monosporous generation were found to fruit just as readily and as perfectly as compound mycelia derived from many spores of a wild fruit-body.

Clamp-connections were found in the new cultures: (1) on each of two mycelia which originated from single spores produced by a fruit-body of the sixth successive monosporous generation, and (2) on each of four mycelia which originated from single spores produced by a fruit-body of the seventh successive monosporous generation. These results are in complete accord with those given in my first paper.

The additional facts just described, which again show that monosporous mycelia produce clamp-connections and fruit readily and perfectly, afford strong confirmatory evidence of the correctness of the conclusion to which I came in my first paper, namely, that *Coprinus sterquilinus* is homothallic.

## V. *Coprinus stercorarius.*

In a new series of monosporous cultures of *Coprinus stercorarius*, clamp-connections were formed: (1) on each of three mycelia which originated from single spores of a wild fruit-body, and (2) on each of six mycelia which originated from single spores produced by a fruit-body of monosporous origin. All these nine mycelia produced clamp-connections two days after isolation and transference to a new plate. They therefore behaved exactly like the monosporous mycelia described in my first paper.

Three of the mycelia of the second series (2) were allowed to continue their development on dung-agar plates, and there they produced small perfect fruit-bodies which shed spores. It thus was proved that monosporous mycelia of *Coprinus stercorarius*, even of the second monosporous generation, are able to fruit in a perfectly normal manner.

The additional facts just described, which again show that monosporous mycelia produce clamp-connections and fruit readily and perfectly, afford strong confirmatory evidence of the correctness of the conclusion to which I came in my first paper, namely that *Coprinus stercorarius* is homothallic.

Brefeld* shows clamp-connections as occurring on a monosporous mycelium of *C. stercorarius*. His observations and my own are therefore in accord. On the other hand, Kniep†, without giving details of his evidence, states that this fungus is heterothallic. It is, therefore, possible that there may be in existence both homothallic and heterothallic strains of *C. stercorarius*. Further experiment with diverse strains obtained from different localities can alone teach us the truth about this matter.

## VI. *Coprinus lagopus.*

In the series of experiments upon *Coprinus lagopus* recorded in my first paper I found that clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body, (2) on each of three mycelia of monosporous origin derived from spores produced by a fruit-body of monosporous origin, and (3) on a compound mycelium

* O. Brefeld, Untersuchungen, Leipzig, Heft III, 1877, p. 206 under Fig. 3 *b*; also Taf. I, Fig. 3 *b*.

† Hans Kniep, *loc. cit.* p. 13.

of polysporous origin derived from many spores produced by a fruit-body of monosporous origin. I therefore came to the conclusion that *C. lagopus* is homothallic. There was nothing to suggest that this species might be heterothallic.

After sending my first paper to the press in May 1921, I isolated another series of monosporous mycelia of *C. lagopus* and, as I was leaving Winnipeg for Vancouver, took the cultures with me. To my great surprise, I found that these mycelia did not produce any clamp-connections. During the summer of 1921, circumstances prevented me from making any further experiments; but, on returning to Winnipeg in September, I at once began to investigate *Coprinus lagopus* again with the object of solving the problem of the sex of the mycelia in this species.

Altogether, since writing my first paper, I have made 59 new monosporous cultures of *C. lagopus*. Owing to the fact that some of the spore-deposits of *C. lagopus* had been destroyed after the completion of my first paper, I was compelled to use new spore material. The new spores were provided by ten different fruit-bodies. To the best of my knowledge the mycelia were isolated in exactly the same manner as formerly. They were all transferred to agar plates and, later, 29 of them were transferred to sterilised dung in wide test-tubes; and they were all kept in pure culture for 50 days and most of them for from two to three months. Examination with the microscope yielded a result just the opposite of that found in the experiments recorded in my first paper, for not a single one of all the 59 monosporous mycelia produced any clamp-connections whatever. On the other hand, polysporous mycelia derived from several spores produced clamp-connections within four or five days after the spores were sown.

These new observations naturally suggested that the strains of *Coprinus lagopus* with which I was working were heterothallic. Therefore, assuming that the monosporous mycelia were all unisexual and would behave in the same manner as Blakeslee's (+) and (−) strains of Mucor and as Mlle Bensaude's (+) and (−) strains of her *Coprinus fimetarius*, I paired 23 of the mycelia with No. 14 and 7 with No. 46, Nos. 14 and 46 being taken as standards. The results of making these 30 pairs are shown in Table I. In the fourth column of this table the blanks indicate that no observations with regard to fruiting were recorded.

Of the 30 pairs of mycelia, 17 developed clamp-connections in a regular manner, while 13 did not develop any clamp-connections whatever. It was therefore supposed that a (+) and a (−) sexual strain must have been present in each of the

*Table I.* Coprinus lagopus: *The Effect of Pairing Monosporous Mycelia.*

| Mycelial pairs | Sexual signs | Clamp-connections 4–7 days after pairing | Fruit-body development in the plates |
|---|---|---|---|
| 3 × 14 | + + | absent | imperfect |
| 4 × 14 | + + | ,, | ,, |
| 6 × 14 | + + | ,, | ,, |
| 7 × 14 | + + | ,, | ,, |
| 9 × 14 | + + | ,, | ,, |
| 10 × 14 | − + | present | perfect |
| 11 × 14 | − + | ,, | — |
| 12 × 14 | − + | ,, | perfect |
| 13 × 14 | + + | absent | — |
| 15 × 14 | + + | ,, | imperfect |
| 16 × 14 | + + | ,, | ,, |
| 17 × 14 | + + | ,, | ,, |
| 18 × 14 | − + | present | perfect |
| 19 × 14 | − + | ,, | ,, |
| 20 × 14 | − + | ,, | ,, |
| 21 × 14 | + + | absent | imperfect |
| 22 × 14 | + + | ,, | ,, |
| 23 × 14 | − + | present | perfect |
| 25 × 14 | − + | ,, | ,, |
| 26 × 14 | − + | ,, | ,, |
| 27 × 14 | − + | ,, | ,, |
| 28 × 14 | − + | ,, | ,, |
| 29 × 14 | − + | ,, | ,, |
| 47 × 46 | − − | absent | — |
| 48 × 46 | − − | ,, | — |
| 51 × 46 | + − | present | — |
| 52 × 46 | + − | ,, | — |
| 53 × 46 | + − | ,, | — |
| 54 × 46 | + − | ,, | — |
| 55 × 46 | + − | ,, | — |

17 pairs in which clamp-connections had appeared. No. 14 was given a (+) sign, but this was done quite arbitrarily, for morphologically No. 14 did not differ from the other mycelia. The mycelia with which No. 14 had produced clamp-connections were then given a (−) sign, and the mycelia with which No. 14 had not produced clamp-connections were given a (+) sign. Subsequently it was found that clamp-connections were formed when No. 46 was mated with No. 14. Since No. 14 had a (+) sign, it was therefore necessary to give No. 46 a (−) sign. Nos. 51–55 all produced clamp-connections with No. 46. Hence they were given a (+) sign; and, since Nos. 47 and 48 did not yield clamp-connections with No. 46, they were given a (−) sign. All these signs are shown in Table I.

The pairs of mycelia which developed clamp-connections also developed normal fruit-bodies. About a week after the matings had been effected, these fruit-bodies expanded and shed an abundance of their black spores. On the contrary, the pairs of mycelia which remained in the primary condition and did not

develop clamp-connections, gave rise only to imperfect fruit-bodies. These varied from about the size of a pin's head to rudiments 3–4 mm. high. In the larger rudiments, the stipe and pileus were clearly differentiated, but no expansion took place and no spores were ever liberated. It was therefore clear that rapid and perfect production of fruit-bodies was associated in my cultures with the formation of clamp-connections, i.e. with the secondary or diploid condition of the mycelium, and that the production of imperfect fruit-bodies was associated with the non-formation of clamp-connections, i.e. with the primary or haploid condition of the mycelium.

After the results embodied in Table I had been obtained, it was to be expected that mycelia of like signs, if paired, would not produce any clamp-connections. Each of six plates was therefore inoculated with two mycelia of (+) sign, and each of 18 plates with two mycelia of (−) sign. The results of this pairing, which are shown in Table II, did not conform with expectation, for only 16 of the 24 pairs remained without clamp-connections, while clamp-connections soon made their appearance in one of the six (++) pairs and in 7 of the 18 (−−) pairs. It therefore became apparent that the phenomenon of heterothallism in *Coprinus lagopus* is much more complicated than I had at first imagined.

*Table II.* Coprinus lagopus: *The Effect of Pairing Monosporous Mycelia of Like Sign.*

| Mycelial pairs | Sexual signs | Clamp-connections after pairing | Fruit-body development in the plates |
|---|---|---|---|
| 15 × 16 | + + | absent | — |
| 16 × 17 | + + | ,, | — |
| 17 × 21 | + + | ,, | — |
| 21 × 22 | + + | ,, | — |
| 27 × 28 | − − | ,, | — |
| 23 × 26 | − − | present | — |
| 28 × 19 | − − | absent | — |
| 25 × 46 | − − | ,, | — |
| 48 × 47 | − − | ,, | — |
| 18 × 47 | − − | present | — |
| 51 × 15 | + + | absent | — |
| 55 × 16 | + + | present | — |
| 23 × 18 | − − | ,, | perfect |
| 23 × 19 | − − | ,, | ,, |
| 23 × 25 | − − | absent | imperfect |
| 23 × 27 | − − | ,, | ,, |
| 23 × 28 | − − | ,, | ,, |
| 23 × 29 | − − | ,, | ,, |
| 26 × 18 | − − | present | perfect |
| 26 × 19 | − − | ,, | ,, |
| 26 × 25 | − − | absent | imperfect |
| 26 × 27 | − − | present | perfect |
| 26 × 28 | − − | absent | imperfect |
| 26 × 29 | − − | ,, | ,, |

On the strict (+) and (−) theory of sex, one would suppose that if a mycelium *a* were to yield clamp-connections when paired with either *b* or *c*, the sex of the mycelia *b* and *c* would be identical; so that, if *b* and *c* were to be paired, no clamp-connections would be formed. But this is not always the case, for sometimes we may have clamp-connections developed in all the pairs $a \times b$, $a \times c$ and $b \times c$. Thus, as shown in Table I, mycelium No. 14 forms clamp-connections with both Nos. 23 and 26; but the mycelia Nos. 23 and 26 are not identical in sex, for, as shown in Table II, when paired, they yield clamp-connections. With four mycelia instead of three, even greater complications may arise. It thus appears that the factors or genes for sex in *Coprinus lagopus* are not of a simple but of a compound nature.

In the fourth column of Table II are given the results of observation of fruit-body production for 12 (− −) pairs of mycelia. Here again, as in the experiments recorded in Table I, rapid and perfect production of fruit-bodies was associated always with the production of clamp-connections, i.e. with the secondary or diploid condition of the mycelium, while the production of imperfect fruit-bodies was associated always with the absence of clamp-connections and the retention by the mycelium of the primary or haploid condition.

As a result of the experiments which have just been described it became necessary to discard the strict (+) and (−) theory of sexual strains for *C. lagopus*.

Table III shows the results that were actually obtained when seven monosporous mycelia were paired in all the possible ways. In this table, for the sake of conformity with similar tables made by Kniep for *Schizophyllum commune*, the (+) and (−) signs are introduced, but here they have not the same significance as in Tables I and II, for they do not indicate sex but merely the presence (+) or absence (−) of clamp-connections in the pairs.

*Table III.* Coprinus lagopus: *All Possible Pairings of Seven Monosporous Mycelia.*

| | 21 | 22 | 23 | 25 | 26 | 27 | 29 |
|---|---|---|---|---|---|---|---|
| 21 | − | − | + | + | + | + | + |
| 22 | − | − | + | − | + | + | + |
| 23 | + | + | − | − | + | − | − |
| 25 | + | − | − | − | − | − | + |
| 26 | + | + | + | − | − | + | − |
| 27 | + | + | − | − | + | − | − |
| 29 | + | + | − | + | − | − | − |

When the experiments recorded in Table III were being made, a check upon the purity of the seven monosporous mycelia was

obtained by setting out portions of the mycelia in plates by themselves. In none of these sub-cultures were clamp-connections ever produced.

Since, as indicated in Table I, Nos. 23, 25, 26, 27 and 29 all produced clamp-connections with No. 14, it was to be expected on the strict (+) and (−) theory of sex that they would all behave uniformly with respect to other mycelia; but, by looking along the horizontal rows in Table III, it will be at once seen that this expectation was not justified by experience. Thus although with No. 21 they all gave clamp-connections, yet with Nos. 22, 23 and 25 they did not all behave uniformly; for with No. 22 they all produced clamp-connections except No. 25, with No. 23 they none of them produced clamp-connections except No. 26, and with No. 25 they none of them produced clamp-connections except No. 29.

The results given in Table III are identical in their nature with those obtained by Hans Kniep with *Schizophyllum commune**.

## VII. *Coprinus niveus.*

In the series of experiments upon *Coprinus niveus* recorded in my first paper, I found that clamp-connections developed: (1) on each of several mycelia of monosporous origin derived from the spores of a wild fruit-body, (2) on each of two monosporous mycelia derived from spores produced by a fruit-body of monosporous origin, and (3) on a compound mycelium of polysporous origin derived from many spores produced by a fruit-body of monosporous origin. I therefore came to the conclusion that *Coprinus niveus* is homothallic.

In the winter of 1921–22, I made a new series of experiments which yielded results quite different from those previously obtained. The source of the spores was a wild fruit-body which came up spontaneously on horse dung in the laboratory.

Nine monosporous mycelia were isolated and transferred to dung-agar plates and afterwards sub-cultured in other plates; but, even after the lapse of 32 days, they all failed to produce clamp-connections. On the other hand, a compound mycelium of polysporous origin derived from many spores produced clamp connections in abundance ten days after inoculation.

The presence of clamp-connections on the mycelium of polysporous origin and their absence from the nine mycelia of monosporous origin at once suggested that my new strain of *Coprinus niveus* was heterothallic. A complete series of crossings with the nine mycelia was therefore undertaken. The results are shown in Table IV. As before, the numbers above and to

* H. Kniep, *loc. cit.* p. 12.

the left indicate the numbers given to individual mycelia, while the (+) and (−) signs indicate that clamp-connections were present or absent respectively after the crossings had been effected.

*Table IV.* Coprinus niveus: *All Possible Pairings of Nine Monosporous Mycelia.*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | − | − | − | + | − | − | − | − | − |
| 2 | − | − | − | − | − | − | + | + | + |
| 3 | − | − | − | + | − | − | − | − | − |
| 4 | + | − | + | − | + | + | − | − | − |
| 5 | − | − | − | + | − | − | − | − | − |
| 6 | − | − | − | + | − | − | − | − | − |
| 7 | − | + | − | − | − | − | − | − | − |
| 8 | − | + | − | − | − | − | − | − | − |
| 9 | − | + | − | − | − | − | − | − | − |

As is shown in Table IV, Nos. 2 and 3 both failed to form clamp-connections with Nos. 1, 2, 3, 5 and 6. Yet they are not identical sexually, for No. 2 formed clamp-connections with Nos. 7, 8 and 9, whereas No. 3 did not. Similarly Nos. 4 and 5 did not form clamp-connections with Nos. 2, 7, 8 and 9 and yet are not identical sexually, for No. 4 formed clamp-connections with Nos. 1, 3, 5 and 6, whereas No. 5 did not. Moreover, when Nos. 4 and 5 were paired, they yielded clamp-connections. That the monosporous mycelia were pure was ascertained by making sub-cultures of these mycelia in plates at the same time that the pairings were effected. In none of these nine sub-cultures did any clamp-connections make their appearance. This is indicated in Table IV by the (−) sign for 1 × 1, 2 × 2, 3 × 3 ... 9 × 9.

The results embodied in Table IV seem to show conclusively that the strain of *Coprinus niveus* with which my new work has been carried out is heterothallic but that the individual mycelia cannot be regarded as belonging strictly to two opposite strains, (+) and (−). Thus in my new work *C. niveus* has behaved sexually in the same manner as *C. lagopus*.

## VIII. Discussion.

In both of my investigations upon the sex of *Coprinus sterquilinus* and *C. stercorarius*, mycelia of monosporous origin yielded clamp-connections regularly and readily gave rise to normal fruit-bodies. All the evidence so far obtained therefore strongly supports the view already expressed in my first paper, namely, that *Coprinus sterquilinus* and *C. stercorarius* are homothallic.

So far as concerns *Coprinus lagopus* and *C. niveus*, the results of my two investigations are discordant; for, in the first, monosporous mycelia gave rise regularly to clamp-connections whilst, in the second (described in this paper), clamp-connections never appeared in monosporous mycelia (59 isolations for *C. lagopus* and 9 for *C. niveus*) but only after the pairing of two monosporous mycelia presumably of opposite sex. My first investigation therefore led me to believe that *Coprinus lagopus* and *C. niveus* are homothallic, whereas my second one has provided conclusive evidence that there are strains of both these fungi which are heterothallic.

It may be asked: admitting that all the new observations go to show that *Coprinus lagopus* and *C. niveus* are heterothallic, how is it that different results pointing to homothallism were obtained in the first investigation? There appear to be two alternative explanations: (1) in my first investigation some error crept into the work, (2) there are homothallic strains of both these fungi as well as heterothallic.

I have not been able to think of a single source of error in my first work that could account for the results obtained. So far as I know, I used the same method for isolating and cultivating the mycelia for my second investigation as for my first. I do not think that the plates became infected by spores from the air, or that I confused species or spore-deposits; and I certainly saw the clamp-connections described, for I sketched some of them with the camera-lucida. If I made some mistake in method, I must have repeated it quite consistently in every one of my first experiments, for all the results were consistent, all the monosporous mycelia having produced clamp-connections, and I must have avoided this error consistently in my second experiments, for no clamp-connections ever made their appearance in the 68 new monosporous cultures. On the other hand, it is to be remembered that my first investigation was chiefly devoted to the fruiting of monosporous mycelia, that the question of the presence or absence of clamp-connections was taken up only toward its conclusion, and that the number of observations was relatively few. It is also noteworthy that in my second series of experiments with *Coprinus lagopus*, although I used ten different fruit-bodies, I was unable to obtain any more homothallic strains, and therefore at no time have I been able to grow simultaneously homothallic and heterothallic strains of this fungus.

Blakeslee* found that, in the heterothallic Mucors, each monosporous mycelium is either (+) or (−), and that in these

* A. F. Blakeslee, Sexual Dimorphism in Cunninghamella, Botanical Gazette, LXXII, 1921, p. 186.

fungi there is an absence of sexual intergrades. Kniep*, on the other hand, working with *Schizophyllum commune*, found that, while the monosporous mycelia of this fungus usually are unisexual and do not produce clamp-connections, yet occasionally, when kept in pure culture for a long time, a monosporous mycelium may begin to produce clamp-connections and thus pass definitely from the haploid to the diploid condition. Thus we can speak of *Schizophyllum commune* as being heterothallic but as sometimes producing homothallic strains.

Owing to the fact that I am unable to explain my first results on the basis of error in experiment or observation, and taking into account Kniep's work upon *Schizophyllum commune*, it seems difficult to escape the conclusion that in my first investigation I was studying strains of *Coprinus lagopus* and *C. niveus* which were homothallic. On the other hand, my later results, described in this paper, certainly point to the possibility of some error having occurred in my earlier work. I think, therefore, that it is advisable to lay most weight on my second investigation and to conclude that, while *Coprinus lagopus* and *C. niveus* are undoubtedly heterothallic, it is possible that homothallic strains of both these species exist. The question of the existence or non-existence of these homothallic strains will doubtless be decided by future workers.

In finding that the strict (+) and (−) theory of sex is inapplicable to *Coprinus lagopus* and *C. niveus*, I have but confirmed what Hans Kniep discovered in *Schizophyllum commune*. His table for the latter fungus and my Tables III and IV for the two Coprini are identical in general form.

There can be no doubt that in such fungi as *Schizophyllum commune*, *Coprinus lagopus* and *C. niveus*, the factors or genes for sex are not simple but complex in their nature. To what extent this applies to the Hymenomycetes in general can only be determined by new and extensive investigations.

Recently, B. O. Dodge† working with *Ascobolus magnificus* has found that, so far as sex-organs and ascocarps are concerned, monosporous mycelia are self-sterile, but that sexual organs and ascocarps are produced in cultures containing two strains properly chosen. It thus appears that there are heterothallic species not only in the Basidiomycetes but also in the Ascomycetes.

In my first paper, I pointed out that the *Coprinus fimetarius* used by Mlle Bensaude and my own *C. lagopus* might be identical species. I now think them to be identical and shall so regard them in future. Mlle Bensaude worked with only two mono-

* H. Kniep, *loc. cit.* p. 16.

† B. O. Dodge, The Life History of *Ascobolus magnificus*; Origin of the Ascocarp from two Strains, Mycologia, XII, 1920, pp. 115–134.

sporous strains of her fungus. When grown separately, they did not produce clamp-connections and remained sterile; when paired, they produced clamp-connections and fruited well. She therefore regarded them as (+) and (−) strains; but, had she used more sexual strains, she no doubt would have found out how complex sex is in this fungus and also that the strict (+) and (−) theory of sex is here inapplicable. In my experiments, the development of rudimentary fruit-bodies on monosporous mycelia has been very variable. However, it is somewhat remarkable that Mlle Bensaude's two sexual strains, when grown separately, remained entirely sterile.

## IX. Conclusions.

1. *Coprinus sterquilinus* and *C. stercorarius*, as shown by the production of clamp-connections and fruit-bodies in monosporous cultures, are homothallic.

2. *Coprinus sterquilinus* has been successfully cultivated with the production of perfect fruit-bodies for seven successive monosporous generations. The mycelium of the seventh generation was just as vigorous and fruited just as rapidly as the mycelium of the first generation.

3. There are heterothallic strains of *Coprinus lagopus* and *C. niveus*. Fifty-nine monosporous mycelia of *C. lagopus*, grown separately, never produced clamp-connections. When brought together in suitable pairs, the monosporous mycelia soon produced clamp-connections and later perfect fruit-bodies. Similar results were obtained with nine monosporous mycelia of *C. niveus*.

4. *Coprinus lagopus* and *C. niveus* are heterothallic species; but, as indicated by previous experiments, it is possible that they both sometimes give rise to homothallic strains.

5. The question of sex in heterothallic Coprini is complicated by the fact that the sexual strains cannot be strictly divided into (+) and (−) groups.

6. The sexual reactions between the monosporous mycelia in *Coprinus lagopus*, or in *C. niveus*, are similar to those described by Kniep for *Schizophyllum commune*.

The investigations recorded above were carried out in the Botanical Department of the University of Manitoba during my tenure of the Hudson's Bay Company Research Fellowship. In conclusion, I desire to express my sincere thanks to Professor A. H. Reginald Buller for his continued encouragement and valuable advice.

# SLUGS AS MYCOPHAGISTS.

*By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.*

## Introduction.

Slugs eat many fleshy fungi; and in woods and gardens one can often find fruit-bodies which have been more or less damaged by these animals. Fungi, therefore, especially in certain localities and in certain seasons, must be considered as an important source of slug food. Among the fungi which slugs attack may be mentioned: species of Amanita, Pleurotus, Russula, Psalliota, Coprinus, Boletus, Polyporus and Phallus. Leathery fungi, e.g. *Polystictus versicolor, Stereum hirsutum* and *Schizophyllum commune,* and gelatinous fungi, e.g. *Hirneola auricula-Judae* and *Auricularia mesenterica,* are generally avoided*.

A fruit-body which has been partially eaten by a slug can be easily recognised: (1) by the peculiar manner in which it has been rasped and mined, and (2) by the slug's slime tracks. Slugs are nocturnal animals. During the day, they hide under soil or in dark crevices; but, as darkness comes on, they emerge from their places of concealment and seek their food. They therefore visit the fruit-bodies of fungi during the night, but, as a rule, retire from them with the advent of day. Sometimes, however, a slug which has made a hole on the under side of the pileus or in the top of the upper part of the stipe of a large agaric, such as *Boletus luteus* or *Lactarius piperatus,* remains half-hidden in the hole throughout the day and then may be found by the observer.

## Slug-damaged Fungi in an English Wood.

On September 8, 1920, accompanied by Mr W. B. Grove, I spent an afternoon in a wood at Earlswood, near Birmingham, England, investigating the damage which the slugs had done to the fungi. Out of several hundreds of fruit-bodies of fleshy Hymenomycetes observed, I found very few which had not been visited and partially eaten by slugs. Some of the fruit-bodies had been absolutely ruined by these animals. Thus the stipe of a large *Boletus flavus* had been eaten in two; and the separated pileus had completely lost all its hymenial tubes, whilst the pileus-flesh had become reduced to a thin perforated shell. A slug was found ensconced in one of the cavities of the flesh; and, doubtless, it was only waiting for the night to sate its voracious appetite once more upon the wreck to which it was

* A few experiments upon the edibility of fungi for slugs are recorded in my Researches on Fungi, 1, 1909, p. 229.

clinging. Some other fruit-bodies, e.g. *Russula ochroleuca*, *Lactarius piperatus* and *L. turpis*, were almost equally damaged. The following species were found to have been visited and partially eaten by slugs:

*Species attacked by Slugs.*

| | |
|---|---|
| Amanita rubescens. | Laccaria laccata. |
| Amanitopsis vaginata. | Hypholoma fasciculare. |
| Clitocybe clavipes. | H. sublateritium. |
| Russula emetica. | Flammula sapinea. |
| R. ochroleuca. | Paxillus involutus. |
| R. sardonia. | Cortinarius anomalus. |
| R. heterophylla. | C. paleaceus. |
| R. nigricans. | C. caninus. |
| R. adusta. | C. rigidus. |
| Lactarius piperatus. | Boletus flavus. |
| L. subdulcis. | B. chrysenteron. |
| L. glyciosmus. | B. scaber. |
| L. turpis. | Clavaria cinerea. |

The following species were found not to have been eaten by slugs:

*Species not attacked by Slugs.*

| | |
|---|---|
| Lactarius quietus. | Inocybe geophylla. |
| L. rufus. | Tubaria furfuracea. |
| Collybia butyracea. | Cortinarius sanguineus. |
| Flammula inopus. | Polystictus versicolor. |
| Inocybe asterospora. | Lycoperdon pyriforme. |

Of the species attacked, some, e.g. the Russulae, were damaged much more than others. Scarcely a single fruit-body of any species of Russula could be found which had not been partially eaten. Very few of the fruit-bodies of *Hypholoma fasciculare*, *Laccaria laccata* and *Lactarius glyciosmus* had been eaten and these only slightly, so that it seems that slugs do not much relish these species.

Of the species not attacked by slugs only single fruit-bodies were found of *Flammula inopus*, *Inocybe asterospora* and *Cortinarius sanguineus*, and a few fruit-bodies only of the relatively tiny *Inocybe geophylla* and *Tubaria furfuracea*, so that it is possible that, if the fruit-bodies of these fungi had been more numerous, some of them might have been found attacked. The species which seemed to have been definitely avoided by slugs were *Lactarius quietus*, *L. rufus*, *Collybia butyracea*, *Polystictus versicolor* and *Lycoperdon pyriforme**.

Two species of slugs were found upon the fungi, a larger

* These five species are also distasteful to human beings.

reddish one about one inch long and a smaller darker one. Mr P. T. Deakin kindly identified the former as *Arion subfuscus* var. *aurantiaca* and the latter as a Limax. The specimens submitted for the Limax were too immature for exact identification.

*Polystictus versicolor, Stereum hirsutum,* and other tough and leathery fungi, are probably protected against the ravages of slugs by their physical consistence; while *Lactarius quietus, L. rufus, L. glyciosmus, Collybia butyracea, Laccaria laccata* and *Lycoperdon pyriforme* are more or less protected against slugs by their chemical contents. The majority of fleshy fungi, however, seem to be in no way protected against slugs, and some of the commonest species, e.g. those of Russula, Amanita, Amanitopsis and Boletus, often suffer most. On the whole, the very soft-fleshed species seem to be the most relished by slugs, and these animals are particularly fond of the soft parenchymatous tissues of the Lactarii and of the soft hymenial tubes and flesh of many Boleti. Voglino has supposed that slugs are important agents in bringing about the dissemination and germination of the spores of Russulae, etc., and is inclined to believe in the existence of symbiotic relations between slugs and Hymenomycetes*. I am rather of the opinion that, when a slug attacks a fruit-body, the advantage is chiefly, if not entirely, on the side of the slug and that, from the point of view of the fungus, the slug is a troublesome ectoparasite. As I have pointed out elsewhere, the fruit-bodies of the Hymenomycetes are beautifully organised to secure the dissemination of the spores by the wind and their injury by slugs certainly prevents a great many spores from being liberated†.

### Absence of Slugs from a Wood in Central Canada.

In the late autumn of 1920, I spent several days at Kenora on the Lake of the Woods, central Canada, studying the fleshy fungi in the woods; and, although I made a careful search, I could not find a single agaric damaged by a slug.

Slugs, which are common in England and in the extreme west of Canada (British Columbia), where the climate is damp and moderately warm, are rare in central Canada, where the climate is very dry and relatively cold. Most native-born Manitobans, so far as I can find out by enquiry, have never seen a living slug; and there can be no doubt that the big species of Limax, Arion, etc., which abound in gardens and woods in England, are entirely absent from central Canada. Nevertheless, Mr J. W. Wallis of Winnipeg has assured me that he once found some small slugs living wild in the open in Manitoba; and I, myself,

* Cf. my Researches on Fungi, I, 1909, pp. 226–227.
† *Ibid.* p. 228.

have seen one small slug in a greenhouse at Winnipeg. However, I have never yet seen a slug in any of the woods of central Canada.

Since fleshy fungi, e.g. Russulae, Lactarii, Amanitae, Cortinarii, etc., occur in great variety and numbers in the woods of central Canada, and since slugs do not occur in these woods or are very rare there, it seems safe to infer that fleshy fungi, such as Russulae, Lactarii, Amanitae, Cortinarii, etc., in no way depend upon slugs for the dissemination or germination of their spores.

### Some Conclusions.

We may conclude from the above observations: (1) that slugs, under natural conditions, may attack and feed upon most species of fleshy Hymenomycetes occurring in woods, (2) that the attacks of the slugs often seriously interfere with the production and liberation of spores by individual fruit-bodies, (3) that most species of fleshy fungi are in no way protected against slugs, and (4) that very many species of fleshy fungi do not depend upon slugs for the dissemination or germination of their spores.

### The Finding of Fungi by Slugs.

Before eating a fungus, a slug must first find it. Now, according to zoologists, the common slugs of English fields and woods, e.g. *Limax maximus* and *Arion ater*, although possessing eyes, can see clearly for a distance of only 1 or 2 mm. and find their food chiefly by their sense of smell*. We must therefore suppose that slugs find the fungi upon which they feed chemotactically, i.e. by changing their direction of locomotion in response to the chemical stimulus arising from the odoriferous substances which the fungi give off.

### Previous Chemotactic Experiments.

As evidence that slugs find their food by their sense of smell A. H. Cooke cites the following observations†:

"M. Parenteau was one day walking along a dusty high-road, when he noticed, near the middle of the road, an empty bean-pod and two Arions eating it. Attributing the meeting of feeders and food to mere chance, he was walking on when he noticed a second bean-pod, and, about two yards away from it, a third Arion, hurrying straight towards it. When the Arion had yet

* V. Willem, Arch. Biol. XII, 1892, p. 57, cited from A. H. Cooke, Cambridge Natural History, Molluscs, 1895, p. 185.

† A. H. Cooke, Cambridge Natural History, Molluscs, 1895, pp. 193–194. These observations were first recorded by Moquin-Tandon in his Mollusques de France, I, p. 130.

more than a yard to traverse, M. Parenteau picked up the bean and put it in his pocket. The Arion stopped, raised its head, and turned in every direction, waving its tentacles, but without advancing. M. Parenteau then carried the bean to the other side of the road, and put it in a small hole behind a piece of stone. The Arion, after a moment's indecision, started off straight for the bean. Again the position of the precious morsel was changed, and again the Arion made for it, this time without being further tantalised.

M. Moquin-Tandon noticed, one rainy day in the botanical gardens at Toulouse, two *Limax maximus* approaching a rotten apple from different directions. He changed the position of the apple several times, placing it at a sufficient distance to be sure they could not see it, but they always hit it off correctly, after raising their heads and moving their long tentacles in every direction. It then occurred to him to hold the apple in the air, some centimetres above the head of the Limax. They perceived where it was, raised their heads and lengthened their necks, endeavouring to find some solid body on which to climb to their food."

As confirming M. Moquin-Tandon's experiment, and as further evidence that the olfactory sense in Limaces is extremely acute, J. W. Taylor in his Monograph relates the following*:

"Mr L. E. Adams, about ten o'clock, one dark, windy, and wet evening in August, 1897, at Clifton, Derbyshire, saw a *Limax maximus* crawling directly toward a plate upon the lawn, containing the remains of the dog's dinner; when first observed the slug was about six feet distant from the plate, but within thirty minutes had reached it; the plate was then removed to a second position, about six feet away, but in another direction; the slug almost immediately changed its course, and again made straight towards the plate, on again nearing it the same process was repeated with the same result, the plate being finally removed and placed in a fourth position, eight feet away, and directly to the leeward of the slug, yet in a little more than half-an-hour the slug had reached the plate."

Ernst Stahl† of Jena, whilst carrying out some extended investigations upon the chemical and physical means by which certain plants are protected from the attacks of slugs and snails, incidentally convinced himself by experiment that slugs find their way to their food by their sense of smell. He placed a

* John W. Taylor, Monograph of the Land and Freshwater Mollusca of the British Isles (Testacellidae, Limacidae, Arionidae), Leeds, 1907, p. 37.

† Ernst Stahl, Pflanzen und Schnecken, Eine biologische Studie über die Schutzmittel der Pflanzen gegen Schneckenfrass, Jena, 1888, pp. 15–16, footnote.

slug (Limax) upon a moistened dinner plate and with his mouth blew gently upon it in a horizontal direction. He found that the current of air so produced had no particular effect upon the slug's movements. He then put a cup fungus, *Peziza vesiculosa*, between his mouth and the slug and continued blowing. The slug then immediately changed its behaviour. If the slug's head had been turned away from the experimenter, the slug raised it, moved its tentacles about in the air, soon turned the front part of its body round, and then steered, as the blowing continued, straight toward the fungus. That the slug sought its food by its sense of smell and not by its sense of sight, Stahl showed as follows. He blew over the Peziza as before and waited until the slug had approached to within about 1 cm. of its surface. He then took another Peziza, placed it upon the opposite side of the plate, and blew over it toward the slug. The new current of air was thus made to move in the opposite direction to the first one and to pass over the second fungus, the slug, and the first fungus successively. Stahl then observed several times that the slug, although only 1 cm. away from the first fungus and many cm. away from the second, turned round, left the near-by first fungus, and crawled directly toward the distant second one from which the current of air was coming. It was only when the slug was almost touching the first fungus that Stahl was unsuccessful in trying to induce the slug to turn round and seek the second.

## New Chemotactic Experiments.

With a view to testing the supposition that slugs find their food, and in particular find fungi, by their sense of smell, I have made a series of experiments, under conditions as natural as possible, upon the attraction of *Limax maximus* to *Phallus impudicus* and to certain Hymenomycetes. Before giving an account of these experiments, however, it will be necessary for me to make a few preliminary remarks upon both the Limax and the Phallus.

According to Simroth and Scharff, the food of *Limax maximus* consists of non-chlorophyllaceous substances, while anything containing chlorophyll is as a rule refused*; and W. A. Gain considers *Limax maximus* a very dainty feeder, preferring fungi to all other foods†. Stahl‡ divided slugs and snails into *omnivora* and *specialists* and states that *Limax maximus* is a specialist which feeds chiefly on fungi.

*Limax maximus*, like most other slugs, hides during the day in crevices under stones or in the soil, and only emerges from its

* A. H. Cooke, *loc. cit.* p. 31. † *Ibid.* p. 32.
‡ E. Stahl, *loc. cit.* p. 15.

place of retreat as darkness is coming on. It was therefore necessary for me to make my experiments during the evening and night. Slugs and snails possess to a considerable degree the power of *homing*, i.e. of returning to the same hiding place day after day, after their night excursions in search of food*. My observations have convinced me that *Limax maximus* is a homing slug. The slugs used in my experiment had a fixed abode to which they always returned after their nocturnal peregrinations; and the realisation of this fact was of considerable help to me in suitably arranging the position of the fungus fruit-bodies which I wished the slugs to visit.

It has been calculated that an average-sized snail of moderate pace progresses at the rate of about a mile in 16 days and 14 hours†. This works out at about 13·3 ft. per hour. The rate of movement of *Limax maximus* is probably not very different from that of a snail. On one occasion I found that a *Limax maximus* had travelled from one point to another 12 ft. distant in 1 hour and 20 minutes; but the course taken was not the shortest possible, so that I have no doubt that the actual pace of the slug somewhat exceeded 10 ft. an hour.

*Phallus impudicus*—the Stink-horn Fungus—as every botanist is aware, is one of the most remarkable of all fungi. The young fruit-body—sometimes known as a Devil's Egg—is a soft spherical white ball, a little larger than a hen's egg; and it is protected upon its exterior by a thick gelatinous peridium. At maturity, the ball suddenly bursts at the top, and then there emerges from it in the course of about half-an-hour a sort of Jack-in-the-Box made up of a long, white, hollow, spongy, bread-like stipe bearing at its free end a conical cap covered with dark green slime. The slime contains sugar and millions of green spores, and from it issues a very powerful and offensive odour. Dung flies are attracted to the fungus by the smell, alight upon the green cap, lick up the sweet slime, and carry away the spores upon their straggling legs and inquisitive proboscides and within their alimentary canals. Thus the spores of the fungi are disseminated through the agency of insects.

The smell from the cap of an expanded *Phallus impudicus* attracts not only flies during the day but also slugs during the night. Early in the morning I have several times found an expanded fruit-body with a stipe which had been half-eaten by slugs during the previous night, the slime left upon the fungus and the nature of the damage affording a clear indication of the identity of the marauders; and, in the twilight of the evening, I have sometimes found a slug, *Limax maximus*, actually upon a Phallus engaged in feeding.

* A. H. Cooke, *loc. cit.* pp. 34–36. † *Ibid.* p. 46.

*Experiment I.* At my father's house at Birmingham, England, there is a smooth, well-compressed, gravel carriage-way which is oval in form, 40 ft. wide and 60 ft. long. On a border, at the edge of the gravelled area, one evening in August as darkness was setting in, I found an expanded Phallus upon which a slug, *Limax maximus*, was feeding. I removed the slug and set the fungus upon the gravel at a distance of 10 ft. from the edge of the border. The next morning I found that a slug had visited the fungus upon the gravel, and the slime-track revealed that the slug had come from the border where I had first found the fungus with a slug feeding upon it. The track was very direct from the border to the fungus. It therefore appeared that the Phallus had attracted the slug chemotactically for a distance of at least 10 ft.

*Experiment II.* Shortly after making the above experiment, on August 28, 1920, I visited Sutton Park, Warwickshire, and there procured nine large Phallus balls from under a Holly bush. The balls were full-grown, but still quite odourless; and their stipes were beginning to elongate, for I could feel them in some of the balls pressing upwards against the top of the peridium. I took the balls home to my father's garden, planted them in damp soil in pots, and set the pots in the greenhouse. Two days afterwards, one of the balls opened and a tall stipe covered with a strongly odorous dark-green cap emerged. In the evening I set the expanded Phallus in the middle of the gravelled area. Next morning I found that the fungus had been visited by a slug which, as indicated by its slime-track, had crept over the gravel for a distance of about 21 ft.

*Experiment III.* The other Phallus fruit-bodies opened one by one, and with them I made several other experiments like the one just described. In one of them a slug came at night about 24 ft. over the gravel to two fruit-bodies which were in one pot, ate a piece out of each of the two stipes, and then crept between the bottom of the pot and the gravel. When I raised the pot in the morning, in order to take it to a place where the Bluebottle flies could not eat up all the green slime, I found the slug beneath. The slug was kindly identified for me by Mr P. T. Deakin as *Limax maximus* var. *obscura*.

On three other nights I placed pots with expanded Phallus fruit-bodies in the middle of the gravelled area, but no slugs visited them. This may have been due in part to the paucity of slugs in the borders and in part to the weather being rainy and windy. The successful experiments were performed on still nights. Slime tracks were only found in the morning upon the gravel when a slug had visited a Phallus during the previous night.

The above observations show that *Limax maximus*, under natural conditions, guided by its sense of smell, sometimes travels from 21 to 24 ft. toward an expanded fruit-body of *Phallus impudicus* and that, upon coming in contact with the fruit-body, it feeds upon the stipe.

I employed *Phallus impudicus* for my first experiments upon the chemotaxis of slugs because of its very powerful odour and the convenience with which I could procure and handle its fruit-bodies; but I have found that similar experiments can be performed with Boleti and Agaricineae.

*Experiment IV.* On September 8, I procured three fresh fruit-bodies of *Boletus scaber* from a wood and, in the evening of September 9, placed them upon the gravelled area at a distance of 10 ft. from the border. During the night a slug came from the border across the gravel to the fruit-bodies and ate three holes in the top of one of the pilei. A similar experiment made at the same time with a large fruit-body of *Russula heterophylla* was also successful.

*Experiment V.* The next evening, September 10, about 8 p.m., I placed upon the gravel three little heaps of hymenomycetous fruit-bodies. In the first heap were the three fruit-bodies of *Boletus scaber* which had been used the night before, in the second three fruit-bodies of *Cortinarius caninus*, and in the third three fruit-bodies of *Russula nigricans*. Each heap was made at a distance of 12 ft. from the border and the three heaps were in a row, the central heap being that of *Boletus scaber* and the intervals between the heaps being 4 ft. Having had considerable difficulty in some of the previous experiments in tracking the slime-trail upon the gravel owing to the intermittency or thinness of the trail and owing to the effects of dew, I placed some large fern leaves in a line along the edge of the gravel by the border, so that, if a slug crossed the line, it would leave a trail behind which could be easily detected. The night was a very dark one. About 10 p.m. I went out with a lighted taper to see what was happening. On examining the fern leaves I found upon the leaflets a shinging slime-trail, the direction of which proved that the fern line had already been crossed by a slug. I then hunted about on the gravel and found the slug, a *Limax maximus*, about 4 inches long, actually on its way to the fungi. The slug was already 4 ft. from the border whence it had come and was heading in the right direction to reach the row of fungus heaps some 8 ft. distant. I noticed, however, that the path of approach to the fungi was by no means a straight line but was made up of a series of curves. At 10.45 p.m. I found the slug about 4 ft. from two of the heaps of fungi, and at 11.20 p.m. I found the slug actually upon one of the fruit-

bodies of *Boletus scaber* quietly feeding. No other slug could be seen anywhere. The next morning I detected the slime-trail of the slug in the neighbourhood of the heap of Boleti but nowhere else, the trail having been weakened or destroyed by dew formation; and the slug had disappeared. In all probability the slug had returned to the border whence it had originally come.

*Experiment VI.* The next evening, September 11, I set out upon the gravel the same three heaps of fruit-bodies as had been used the night before. Again the heaps were made in a row parallel to the edge of the border, the intervals between the heaps being 4 ft., the *Boletus scaber* heap occupying the central position in the row and the *Cortinarius caninus* and *Russula nigricans* heaps the end positions. However, the arrangement of the heaps differed from that of the night before in that each heap instead of being only 12 ft. from the edge of the border was now 20 ft. The condition of the *Russula nigricans* and *Cortinarius caninus* fruit-bodies was still good, but the *Boletus scaber* fruit-bodies were now in an advanced stage of putrescence. The evil state of the *Boletus scaber* fruit-bodies was perhaps the reason why, as we shall see in the sequel, they were not visited by a slug in this particular experiment. The night was again very dark and still. At 9.40 p.m., with the help of a lighted taper, I found a *Limax maximus* which had just emerged from its hiding place and which was moving behind a block of sandstone in the border 21 ft. from the fungi. At 11 p.m. I went out again and found that the slug had already travelled 11 ft. upon the gravel toward the fungi from which it was now only 9 ft. distant. I watched the slug for a little time but, being afraid of disturbing it too much, soon retired into the house. At 12 p.m. I sought the slug again and found it 6·5 ft. away from the row of fungi; but, to my surprise, it was moving away from the row of fungi instead of toward it. At 1 a.m., the slug was 5 ft. away from each of the heaps of *Boletus scaber* and of *Russula nigricans*; at 1.30 a.m., about 2 ft. away; and, finally, at 2 a.m., actually upon one of the fruit-bodies of *Russula nigricans* devouring the gills. Thus the slug, after some five hours of wandering, had at last succeeded in finding one of the heaps of fungi set 20 ft. from the edge of the border where the slug had first been seen.

The slug, between 9.40 p.m. and 11 p.m., must have travelled almost directly toward the fungi; for, during this period, it traversed 1 ft. of border and 11 ft. of gravel in the direct line of its journey. But between 11 p.m. and 1 a.m. this rapid progress was not kept up and there was a great waste of time, for during this period the net advance of the slug toward the fungi

was only 4 ft. The slug, as the track showed the next morning, seems, during these two hours, to have wandered more or less round and round in a knotted manner as if it had had some difficulty in detecting the scent of the fungi. As it happened, the slug was obliged to cross the line where the heaps of fungi had lain during the previous night and day, and it is therefore possible that the fungi had in some way scented the ground and that the scent had mis-led the slug. It is also possible that variations in air currents took place in such a way as to send the odour of the fungi in the heaps toward the slug only very intermittently. But, whatever may be the true explanation, it is certain that between 11 p.m. and 1 a.m. the slug lost much time and spent a considerable amount of energy in fruitless wandering.

There was nothing upon the gravel for the slug to eat except the fungi I had placed there and, if the slug had continued in the direction in which it set out without finding the fungi, it would have traversed a gravel desert 60 ft. across.

At 2 a.m., as soon as I had found the slug which had been under observation, upon a *Russula nigricans* fruit-body, I hunted carefully over the gravelled area for other slugs. I could find one more slug only—another *Limax maximus*—which had come out of the border and was heading straight for the row of fruit-body heaps from which it was only 8 ft. distant; but whether or not this second slug ever reached one of the heaps I cannot say, as at 2.5 a.m. I retired to bed and, in the morning, could not clearly distinguish the trail.

In the morning of September 12, I found that the slug which had visited the *Russula nigricans* fruit-bodies was no longer to be seen upon the gravel. Doubtless, it had once more retired to the border. It is doubtful whether the return journey could have been accomplished in less than two hours. It appears, therefore, that our *Limax maximus*, with the object of feeding upon a fungus and then returning home, must have spent some six or seven hours in a single night in wandering over the gravel where the fungus was. Such an effort shows how strongly fungi attract slugs of the *Limax maximus* species. Doubtless, the slugs in woods are also attracted to fungi from a distance of many feet. In view of my observations on *Limax maximus*, the success with which slugs in woods find out the fleshy Hymenomycetes can no longer be a matter for astonishment.

*Experiment VII.* On September 12, I made a fourth experiment with hymenomycetous fruit-bodies. On this occasion I used the *Russula nigricans* and *Cortinarius caninus* heaps alone, as the *Boletus scaber* fruit-bodies had now become thoroughly

decomposed. I set the two heaps of fruit-bodies on the gravel 4 ft. apart and each 21 ft. distant from the place in the border from which the slugs usually issued on their nocturnal forays; but the new position of the fungi was such that the slugs, if they sought the fungi, would be obliged to travel not in the direction taken during the previous two nights but in a direction making therewith an angle of 45°. The night was very still, and dark; there was no moon, and overhanging trees shut out from that part of the gravel which the slugs would be obliged to cross even the faint light of the stars. At 11.30 p.m., with the help of a taper, I found a slug moving toward the two heaps of fungi and only 9 ft. distant from them. It was a *Limax maximus*, exactly resembling the two I had seen the previous night, and its four horns were spread out in the air as though they were being used to detect the direction from which the odour of the fungi was coming. I could see by the slime-trail upon fallen leaves and gravel stones that the slug was making a gentle sweep toward the *Russula nigricans* fruit-bodies and that it had kept upon a steady course since it had left the border. Next morning, I found that the *Russula nigricans* fruit-bodies had been visited by two slugs during the night, for there were four slime-tracks passing between them and the border. Moreover, one large cavity and two smaller ones had been made by the slugs in one of the pilei. By careful tracking, I found that one of the slugs which we will assume was homeward bound, after feeding upon one of the *Russula nigricans* fruit-bodies, had made a détour and had visited the heap of *Cortinarius caninus* fruit-bodies. Here it had crept on to one of the pilei and tasted the gills, and then it had retired by a somewhat sinuous course to the border from which it had set out, 21 ft. away. The actual distance traversed by this slug in the course of its excursion to the two heaps of fungi must have been at least 50 ft.

The circumference of a circle with a radius of 21 ft. is 132 ft. The width of my heap of *Russula nigricans* fruit-bodies was 4 inches. Supposing, therefore, that the heap of fruit-bodies were on the circumference of a circle with a radius of 21 ft., as was actually the case in the experiment just recorded, and supposing, further, that a slug were to start from the centre of this circle and move at random radially outwards for a distance of 21 ft., the chances of the slug meeting the heap of fruit-bodies would be 395 to 1 against. Simple mathematical calculations of this kind afford strong evidence that the slugs in my experiments did not find the fungi in the night by chance but through the guidance of some stimulus coming from the fungi and received by their sense organs.

Immediately after making Experiment VII, I was obliged to leave England to return to my duties in Canada. My investigations upon the finding of fungi by slugs were thereby brought to an end.

## Slugs and Mustard Gas.

There can be but little doubt that the stimulus which comes from the fungi to the slugs and which guides these animals on their foraging expeditions is gaseous in nature. It has been recently shown by Dr Paul Bartsch of the Smithsonian Institute, Washington, that *Limax maximus* is extraordinarily sensitive to certain gases. A few years ago a number of slugs of this species, which were under observation in his home, escaped from the box in which they had been confined. Their behaviour in the furnace room showed that they were sensitive to the fumes coming from the furnace and, in response thereto, made characteristic movements of their tentacles. After the United States entered the War and the need for a gas detector arose in connection with the fighting at the front, Dr Bartsch recalled his furnace-room observations. A very brief period of experimentation then revealed the extraordinary sensitiveness of *Limax maximus* to mustard gas, and such startling results were obtained that within two hours after the first experiment had been made, the Allied forces were advised by cable of the possibilities of using the slug as a gas detector. Dr Bartsch found that the tentacles of *Limax maximus* are sensitive to a dilution of 1 in 10,000,000 of mustard gas, and that they make characteristic responses indicating the degree of dilution. Dr Bartsch also found that man reacts to a dilution of 1 in 4,000,000. *Limax maximus*, therefore, is much more sensitive to the presence of mustard gas than man*. If *Limax maximus* is thus so extraordinarily sensitive to one gas, we have every reason for believing that it is extraordinarily sensitive to other gases, particularly those which emanate from its food substances such as fungi. If we assume such a sensitiveness, it is not difficult to imagine how it is that *Limax maximus* finds its way unerringly over a distance of many feet to the fruit-bodies of Phallus, Boletus, Russula, etc., which it devours with such avidity. The sense of smell in slugs, like that in dogs, is doubtless much more acute than in human beings.

* Paul Bartsch, Our Poison Gas Detector and How It was Discovered, Abstract of an Address delivered on Feb. 7, 1920, to the Biological Society of Washington, U.S.A. I read a paper entitled "Upon the Chemotactic Attraction of Fungi for Slugs" at Chicago on Dec. 30, 1920, before the Ecological Society of America. Subsequently Dr R. F. Griggs called my attention to Dr Bartsch's work, and then Dr Bartsch kindly sent me an abstract of his Address.

### Conclusions.

(1) The successful experiments with *Phallus impudicus*, *Russula heterophylla* and *R. nigricans*, described above, clearly show that the fruit-bodies of these fungi, under certain conditions in the open, attract *Limax maximus* from a distance of at least 10 to 21 ft.

(2) Having regard to the well-known short-sightedness of slugs, to the fact that slugs find their food at night, and to the sensitiveness of *Limax maximus* to mustard gas when diluted to one part in ten million, my observations and experiments lead me to suppose that fungus-eating slugs react at a distance to the odours given off by fleshy fungi, and that in woods and gardens they find the fungi upon which they feed by their sense of smell.

(3) The chemotaxis of slugs, not merely for fungi but also for garden produce such as lettuce and cabbage, is a subject concerning which our information is still very meagre, but which is very amenable to experimental treatment. If the chemotaxis of slugs were sufficiently elucidated, we might perhaps be able to devise much more efficient means for protecting our gardens from the ravages of slugs than any at present known.

## ON THE SYMPTOMS OF WILTING OF MICHAELMAS DAISIES PRODUCED BY A TOXIN SECRETED BY A CEPHALOSPORIUM.

*By W. J. Dowson, M.A., F.L.S., Royal Horticultural Society's Garden, Wisley, Ripley, Surrey.*

The investigation of a serious and widespread wilt disease of Michaelmas Daisies undertaken at Wisley in the autumn of 1920 and not yet completed has already led to definite results concerning the action of the parasitic fungus involved.

In the present paper it is intended to give only an account of the experiments which led to the conclusion that the symptoms of the disease are due to the secretion of a toxic substance by the parasite. The complete account of the investigation of the disease including the morphology of the parasite is left over for a further paper. In recent literature dealing with wilt diseases due to species of *Fusarium* investigators have suspected that the actual symptoms of wilt are due, not so much to the clogging of the vessels and tracheids of the xylem thereby causing an

interference with the conduction of water, but rather to the action of some toxic substance secreted by the mycelium and taken up in the transpiration current.

Thus, Johnson (1) writing on the Fusarium wilt of tobacco says "nevertheless, from the behaviour of the diseased plants, especially with regard to yellowing and early turgidity, it is not believed that death of the plants is due to clogging of the vessels but rather to toxic materials formed by the parasite, or as a result of parasitic action on the host." Cromwell (2) investigating the Fusarium blight of the Soy bean says, "it seems, therefore, that the symptoms produced result not simply from a mechanical clogging," and he goes on, "a reduction of the activity of the protoplasm due to the possible presence of toxins secreted by the fungus...."

Little work has yet been done on the actual isolation of such a substance. Hutchinson (3) showed in the case of *Bacillus solanacearum* that the toxin secreted by the bacilli in pure culture could be filtered off and when introduced into a living tobacco plant would produce the symptoms of the disease. Quite recently Young and Bennett (4) working with a Fusarium isolated the lethal principle by precipitation with alcohol, redissolved it in water and showed that the solution still possessed its poisonous properties. Professor V. H. Blackman has informed me that similar results have been obtained at the Imperial College of Science, but these have not been published.

The Michaelmas Daisy disease is due to a parasitic fungus which for the present is regarded as a species of Cephalosporium, as only its conidial stage has been ascertained. The fungus has the property of growing in a watery medium in the form of a slimy sheet of mycelium with the copious production of minute conidia.

The cultures were made in 500 cc. flasks containing in one series 200–300 cc. of sterilised water (distilled) and some flamed pieces of diseased Aster stems, long enough to rest against the sides of the flask above the surface of the liquid, and in another series 200–300 cc. of distilled water together with similar pieces of healthy Aster stems. The flasks of the second series were steamed for three hours and when cool were inoculated with mycelium from an agar plate culture. In both series the Cephalosporium mycelium grew downwards on to the surface of the liquid and in four weeks became visible as a thin slimy sheet, the liquid also had become brown in colour and resembled tea in appearance. After being drawn through a Berkfeld filter by a water pump, the liquid thus freed from conidia, and therefore sterile, was poured into a series of small sterilised glass bottles. Another series of similar glass bottles

was filled with boiled tap water, and into both were inserted vigorous green shoots of Michaelmas Daisies. The mouth of each bottle was lightly plugged with cotton wool to keep out dust and to lessen evaporation. All the bottles with their shoots were placed side by side close up to a window. After three days some of the leaves of the shoots in the filtered culture fluid became mottled with paler patches which soon spread and involved the whole surface of the leaves. More leaves became mottled and paler, until on the seventh day nearly all the leaves were bright yellow, shrivelled and dry. The stem which bore them also turned yellow.

(These symptoms of mottling, paling, and yellowing were also observed in inoculation experiments with Cephalosporium.)

The controls in water remained green and turgid until the tenth day when loss of turgor and shrivelling commenced, but no yellowing.

In another series of experiments the filtered fluid was placed in a dialyser of gold-beater's skin suspended in a small beaker of boiled tap water. After three days the water in the beaker outside the dialyser became slightly brown in colour and into this were inserted, as before, green healthy shoots of Michaelmas Daisies. Controls in which the filtered culture fluid was replaced by boiled tap water in the dialyser were also set up. The shoots in these remained as before quite green and turgid for ten days, but those in the dialysed liquid presented mottled leaves after two to three days and at the end of six nearly all were bright yellow and shrivelled.

The effect was more marked and more rapid with the filtered and dialysed liquid. In one of the experiments with the filtered and dialysed liquid, green shoots of the resistant variety "Gladys Donellan" were used to see if this plant behaved towards the toxic substance in a different way than did the susceptible varieties.

The shoot was affected in the same way and in the same time as any other variety tried, thus indicating that "Gladys Donellan" is resistant to the fungus but not to the toxin. Eventually as this experiment and inoculations showed "Gladys Donellan" succumbs as do other varieties of Novae Belgii and Novae Anglii, but takes longer over the process. Or, to put it in another way the mycelium cannot grow so quickly in the wood of "Gladys Donellan" as in other varieties, and therefore produces less toxin in a given time.

The symptoms of wilting noted in the above experiments were repeated almost exactly when Michaelmas Daisy plants were inoculated with the mycelium of the fungus. The rapidity with which the effect was produced indicated the crystalloid

nature of the toxic substance, a supposition which was completely demonstrated by the second series of experiments when the dialyser was employed.

In a third set of experiments hanging drops of the filtered liquid were used, into which were stirred some mesophyll cells obtained by gently scraping the upper surface of a Michaelmas Daisy leaf with a flamed scalpel in a little distilled water. In this way it was possible to watch the effect of bringing the assimilating cells of the host into direct contact with the toxic substance produced by the parasite. After twenty-four hours it was noticed that the chloroplasts of certain cells had altered in position. Instead of lining the longer walls of the palisade cells, they were more numerous towards one or both ends of such cells, so that a gap devoid of chloroplasts appeared either at one end or at the centre. The migration of the chloroplasts went on until at the end of three to four days they were massed together at one or both ends of the cells, but were still quite distinguishable one from another. During the next few days the chloroplasts slowly lost their shape and colour; and by the end of the sixth or seventh day had become an irregularly shaped bright yellow mass. At about this time the cells commenced to plasmolyse indicating the death of the protoplast.

Thus it would appear from these observations together with those on inoculated plants, and on the cut shoots placed in the filtered culture liquid, that the first outward signs of disturbance —the mottling—is due to the action of a toxin on the assimilating tissue, and corresponds with the migration of the chloroplasts, whereby a space devoid of these bodies is left in a large number of cells. The final bright yellow appearance of the leaves, so typical of wilt diseases, is due to the yellow fused-up mass of chloroplasts at the ends of the palisade cells.

## REFERENCES.

(1) Johnson, J. Fusarium Wilt of Tobacco. Journ. Agric. Res. xx, No. 7, 1921, p. 519.

(2) Cromwell, R. O. Fusarium Blight of the Soy Bean and the Relation of Various Factors to Infection. Agric. Exp. Sta. Nebraska. Bull. 14, 1919, p. 14.

(3) Hutchinson, C. M. Rangpur Tobacco Wilt. Mem. Dept. Agric. India, 1913, I, No. 2.

(4) Young, H. C. and Bennett, C. W. Studies in Parasitism in the Fusarium Group. Abs. in Phytopathology, xi. 1921, p. 56.

# OBSERVATIONS ON A DISCOMYCETE FOUND ON MEDLAR FRUITS.

*By H. Wormald, D.Sc., Research Department, South-Eastern Agricultural College, Wye, Kent.*

In 1920 the present writer* recorded the occurrence in this country of a fungus found associated with, and apparently the cause of, a leaf blotch of Medlar trees (*Mespilus germanica* L.). The fungus appeared on the upper surface of the diseased leaves in the form of grey tufts which were often confluent in lines along the principal veins and consisted of chains of almost spherical conidia; these conidia were connected by the slender fusoid bodies known as "disjunctors."

On comparing this fungus with the description and figures given by Schellenberg† it was evident that it was the conidial stage of *Sclerotinia Mespili*. That author found the apothecial stage of the fungus on the mummied Medlar fruits. He stated that these mummies were the result of infection brought about by the transference, by insects, of conidia from diseased leaves to the flowers.

During the latter half of April and the first fortnight of May, 1920, specimens of the leaf blotch were sent to Wye College from five localities, four in Kent, the other in Somersetshire. At two of these a search was made under affected trees for the apothecial form of the fungus. On the trees and also on the ground beneath them were found small dried up undeveloped Medlar fruits but in no case could apothecia be discovered on these. Some of these mummies were collected towards the end of April (1920) and brought to the College where they were placed on the surface of ordinary garden soil in two plant pots; in one pot were placed those collected from the ground, in the other those taken from the tree. The pots were then left exposed in the open.

A microscopic examination of a number of these mummies showed the presence of hyphae in the tissues, and almost invariably numerous, minute, spherical, spore-like bodies (microconidia or sporidia) could be obtained by placing scrapings from the surface of the fruits in water. Cultures were obtained from

* Wormald, H., On the Occurrence in Britain of the Conidial Stage of *Sclerotinia Mespili* Schell., Ann. Appl. Biol. VII, Nos. 2 and 3, pp. 173–6, Dec. 1920.

† Schellenberg, H. C., Ueber *Sclerotinia Mespili* und *Sclerotinia Ariae*, Cent. für Bakt. Abt. 2, Bd. XVII, pp. 188–202, 1907.

the internal mycelium and these resembled in their mode of growth others obtained from conidia taken from the leaves. In such cultures micro-conidia similar to those obtained from the surface of the mummies were invariably produced. No macro-conidia, i.e. similar to those which develop on the leaves, were formed in any of the cultures.

When the pots were examined about the middle of the following February (1921) it was seen that on some of the mummies in the pot containing those collected from the ground, there were present rounded villose brownish outgrowths, 1 to 1·5 mm. in diameter; by March 1 these outgrowths had become more or less conical, being broadest near the base and tapering to a bluntly pointed apex. On March 14 it was noticed that these outgrowths were being devoured by slugs so some of the mummies were brought into the laboratory and placed on moist filter paper in a large Petri dish. Under these conditions development continued and by March 21, the upper portion of each outgrowth had elongated to form a stalk with a slightly swollen terminal knob which in some cases was already provided with a central pore. The pores gradually increased in size, the fructifications becoming cup- or funnel-shaped, and by March 29 well-developed apothecia were present on two of the mummies, which bore ten and twelve sporophores respectively. Three days later the apothecia had become almost plane and were splitting at the margin. As the apothecia reached maturity it was found that, on removing the lid of the dish containing them, the spores were discharged in little visible clouds. Later several such discharges were distinctly seen on placing a mummy bearing ripe apothecia on black velvet exposed to sunlight.

The number of sporophores growing from a mummy was variable; of those left in the open very few attained to their full development owing to the depredations of the slugs, but observations showed that the early stages (the rounded villose outgrowths referred to above) of some ten or more sporophores usually appeared on each mummied fruit. On one of the specimens brought indoors fifteen sporophores were counted.

It is to be noted that the mummies were collected in the spring of 1920 before the trees came into flower; they had therefore passed the previous winter either on the tree or on the ground and, when the apothecia appeared, had been exposed in the open during two (at least) winters. That the medlar fruits do not produce apothecia until the second year after infection was observed by Schellenberg*; the same period is also required by other species of Sclerotinia, as shown by

* *Loc. cit.* p. 189.

Fig. 1. Asci, showing the change which takes place preparatory to the discharge of the spores × 500. *a* and *b*, not vacuolate. *c* and *d*, several vacuoles present. *e* and *f*, one large vacuole in each extending almost to the base.

Aderhold and Ruhland* for *S. fructigena* and the form they refer to *S. laxa*, and by the present author† for *S. cinerea*.

* Aderhold, R., u. Ruhland, W. Zur Kenntnis der Obstbaum-Sklerotinien. Arb. Biol. Abt., Land-u.-Forst. Kaiserl. Gesundheitsamte, IV, pp. 427–42, 1905.

† Wormald, H. On the Occurrence in Britain of the Ascigerous Stage of a "Brown Rot" Fungus. Ann. Bot. XXXV, pp. 125–135, 1921.

From the fructifications examined the following general description was obtained:

The stipe was from 2 to 5 mm. long, pale brown in colour; the receptacle was 3 to 9 mm. in diameter when fully expanded, at length plane or even slightly convex and lobed by the splitting of the margin, pale brown at the edge but darker towards the centre.

On teasing out the hymenium the asci could be found in various stages of development. In some the ascospores were not defined while in those in which the spores were fully formed three stages could be distinguished, viz. (1) asci in which the eight spores extended from the apex to half-way or more down the ascus, the spores being surrounded by protoplasm which extended without vacuoles to the base of the ascus, (2) those in which several vacuoles were present while the spores were pushed nearer the apex so that they extended barely to the middle of the ascus, (3) asci with a single large vacuole extending from the apex almost to the base, the spores being in the upper one-third (or very little more) of the ascus (Text-fig. 1).

The more mature asci, i.e. those in which there was a single large vacuole were on the whole longer and broader than those described under (1) and (2). Thus of those asci which were not vacuolate or which contained several comparatively small vacuoles the dimensions were 144–171 × 7·5–9 $\mu$, while those in which a single large vacuole extended almost the whole length of the ascus were found to measure 159–210 × 9·5–12 $\mu$.

The ascospores were variable in shape and size; they were generally ovoid to ellipsoid but often rather irregular, thus they were sometimes flattened on one side, some were pyriform, others were elongate becoming more or less fusiform and sometimes almost pointed (Text-fig. 2). In size they showed a range of from 10 to 19·5 $\mu$ in length and 5 to 7·5 $\mu$ in width; the great majority however came within the limits 12–16 × 6–7 $\mu$. The average of 100 spores was found to be 13·6 × 6·4 $\mu$. As showing the variation in size and relative proportions the following may be given as examples: 19·5 × 6·5 $\mu$, 10 × 7·5 $\mu$, 10 × 6 $\mu$, 15·5 × 5 $\mu$, 13 × 7 $\mu$. No definite guttules were observed.

The apical pore of the ascus stained blue with iodine. The paraphyses were about the same length as the asci, usually swollen at the apex and unbranched or occasionally with one branch.

One of the few sporophores which reached maturity in the open was found fully expanded on April 8 and was examined microscopically; the asci and ascospores resembled in shape and size those previously examined. It is to be assumed therefore that the morphology of the fungus was not appreciably modified

by bringing the mummies indoors, although the later stages of development, leading to the discharge of the spores, were accelerated.

The foregoing account of the form examined at Wye differs but slightly from that given by Schellenberg for the ascigerous stage of *Sclerotinia Mespili*, if allowance is made for a smaller range of variation in the various morphological characters as recorded by him; the chief discrepancy is in respect to the width of the ascospores. It may be of interest to summarize

Fig. 2. Ascospore, showing range of variation in shape and size. ×650.

the above description in tabular form side by side with that of *S. Mespili*.

| Schellenberg's description of *S. Mespili* summarized | The Medlar Sclerotinia described in this paper |
|---|---|
| The apothecia borne by each mummied fruit were few in number (mostly 1 or 2, but two fruits each bore 3 apothecia, and one had 4). | Apothecia more numerous, 8 to 15 on each fruit except in those cases where most had been eaten by slugs. |
| Stalk of apothecium 3–5 mm. in length (as shown by his figures). | Stalks 2–5 mm. |

| Schellenberg's description of *S. Mespili* summarized | The Medlar Sclerotinia described in this paper |
|---|---|
| Diam. of cup 6–8 mm. | Diam. of cup 3–9 mm. |
| Apothecium bell-shaped to cup-shaped without recurved margin; margin becomes split irregularly. | Apothecium funnel-shaped to cup- or saucer-shaped, at length plane or even slightly convex, and lobed by the splitting of the margin. |
| Asci 160–180 × 8–12 μ (3 asci are figured all with several vacuoles); apical pore stained blue with iodine. | Asci: (*a*) with no vacuoles or several small ones 144–171 × 7·5–9·0 μ. (*b*) with one large vacuole 159–210 × 9·5–12 μ; apical pore stained blue with iodine. |
| Paraphyses as long as asci, slightly swollen at apex (figured as simple or with one branch). | Paraphyses about as long as asci, unbranched or with one branch, usually swollen at tip. |
| Ascospores ellipsoid to ovoid often with a point at each pole, 12–15 × 9–11 μ | Ascospores rather irregular, usually ellipsoid to ovoid, but often pyriform or fusiform, sometimes almost pointed, 10–19·5 × 5–7·5 μ, mostly 12–16 × 6–7 μ. Average size 13·6 × 6·4 μ. |

The mode of development of the ascophore from the mummified fruit is described by Schellenberg as follows: "Wenn aus dem Sclerotium sich ein Apothecium bildet, so tritt die Ablage [? Anlage] als kleiner fleischiger Höcker aus der Frucht heraus. Diese wird gestielt und das knopfförmige Ende breitet sich nach und nach zur Glockenform aus*." This is not in accordance with my own observations, for when the fruits were brought indoors they were under daily observation and it was found that, instead of the primary protuberance becoming stalked and raised up to form the cup, it elongated at its apex; it was thus attenuated upwards and at that stage was more or less conical or flask-shaped so that there was some doubt as to whether it was really a Sclerotinia or whether it was a Sordaria, a genus characterized by a flask-shaped perithecium. No pore appeared however until there was further apical elongation and the development of a terminal head which finally expanded to form the cup.

Schellenberg describes and figures the infection of Medlar leaves with the ascospores. Attempts to induce germination of the ascospores of the Wye specimens failed both in water and on agar plates. Ascospores isolated on the surface of prune juice agar gradually disintegrated without even the protrusion of germ tubes. That fully matured spores behaved thus was shown by catching, on the agar, spores actually shot out from the asci; these could be seen under the microscope in groups of eight and were kept under observation for a week or more, but no germ tubes were developed. Apothecia were then attached

* *Loc. cit.* p. 190.

to twigs of a Medlar tree in the College grounds but no infection of the leaves occurred.

The direct connection between this discomycete and the Monilia with disjunctors found on the leaves was therefore not traced, although the fact, noted above, that a fungus, showing the same habit when grown in plate cultures as that isolated from the leaves, was isolated from the mummies, is suggestive that the two forms are stages in the life cycle of the same fungus. It appears probable therefore that the discomycete is the *Sclerotinia Mespili* of Schellenberg.

SUMMARY.

Mummied Medlar fruits collected from the ground in spring and placed on soil in a pot in the open gave rise to fructifications of a discomycete in the following spring.

The fungus differs but slightly from *Sclerotinia Mespili* as described by Schellenberg.

The differences noticed are:

(1) the ascospores are distinctly narrower;

(2) the stalk of the apothecium develops from the apex of the primary protuberance, not from the base as mentioned by Schellenberg.

## STUDIES IN DISCOMYCETES. III.

*By Jessie S. Bayliss Elliott, D.Sc. Birm., B.Sc. Lond.*

*Arachnopeziza aurata* Fckl. This fungus has been growing on the under side of a log of wood in my garden during the last five years. In all months of the year I have been able to gather material, but growth is most flourishing during the months June to October. The specimens of the fungus I have gathered hardly justified the specific name *aurata* until this summer, for they have always been nearly colourless, as were also specimens I gathered at Porlock Easter and September 1920. Very marked characters—the fascicle of elongated ascospores, the much-branched paraphyses and the white subiculum—leave no doubt as to the identity of the species under consideration. No doubt the deeper colour of the apothecia gathered in July may be correlated with the brilliant summer weather, the log having received more light in its rather shady quarters this year (1921).

Owing to the presence of a subiculum it was possible to make out the early stages in the development of the apothecia which to some extent agree with similar stages figured for *Eremascus albus* Eidam.

The first indications are seen in the coiling of a short hyphal branch which is extremely delicate and fragile arising from one of the horizontal hyphae of the subiculum round another short delicate vertical hypha of the subiculum, and the gradual convergence of the tips until one touches the other: whether there is actual fusion or not could not be made out: at this stage of apparent fusion the tips of the hyphae become swollen and these portions in material which had been fixed in formalin and stained with haematoxylin coloured more deeply. There

Fig. 1. *Arachnopeziza aurata* Fckl. *a*—*j*, successive stages in the development of an apothecium; *a*—*h*, × 800; *i* and *j*, × 400.

is evidently here a primitive type of sexuality—a fusion of similar gametes—such as is figured for *Penicillium crustaceum* and *Eremascus albus*. Sterile hyphae now cluster round and enclose these fertile hyphae arising from their basal portion, with the result that a ball-like colourless perithecial structure appears: this increases in size and soon possesses a pseudo-parenchymatous exterior. Now various cells from this parenchyma grow out into long hairs which at first converge round the summit of the ball-like structure; these then diverge and

form the marginal hairs and those of the encipulum: they are succeeded at the summit by a much denser growth of very fine converging hairs which later stand erect and are the paraphyses of the now fully exposed though still very miniature hymenium of the apothecium: at this stage a very few asci are developed but none contain ascospores.

Although on staining, nuclei were to be seen in the primordial hyphae and in the asci, they were far too small for any attempt at working out details of cytological structure to be made.

*Dasyscypha diplocarpa* Curr. During the mycological foray, Sept. 1920 at Minehead, Dr W. T. Elliott found in the Horner Woods an interesting and very rare Discomycete—*Dasyscypha diplocarpa* Curr. The type specimen was found by Currey at Dartford and apparently there is no other record* of the fungus having been found since that time—fifty-seven years ago. Currey described it under the name of *Peziza diplocarpa* in Linn. Trans. XXIV, p. 153, 1864, giving a coloured illustration of the apothecium and also figures of the paraphyses and spores.

The paraphyses are particularly striking in that each is surmounted by a very large elongated oval septate conidium of a pale green colour: it is these coloured conidia which give the beautiful olive green colour to the disc. Currey in his description, copied by Phillips and Massee, has omitted to mention this and also that the paraphyses are very much branched.

Fig. 2. Branched paraphysis of *D. diplocarpa*.

Phillips mentions that "besides the peculiar bodies Mr Currey regarded as paraphyses he found in the original material slender filiform paraphyses": the latter are to be seen in great numbers but they are merely paraphyses from which the top-heavy conidia have fallen off; this readily happens in mounting portions of the hymenium for microscopical examination, for the conidia are very large (20–50 × 5–6 $\mu$) compared with the extremely filiform lower portion of the branched paraphyses to which they are attached.

The ascospores measure 6–7·5 × 3 $\mu$ and this agrees with the original measurement given by Currey (7 $\mu$): Massee gives the spore measurement 10–12 × 3 $\mu$ and also states that though the spores are for a long time continuous and two guttulate they

* It was recorded from Caughley Wood, Shropshire, at the Worcester Spring Foray, on the 27th May, 1912, see Trans. Brit. Myc. IV, 14 The spores in this gathering measured 7–9 × 3–3·5 $\mu$, and were pale ochraceous at maturity. It was also redescribed by Massee and Crossland from specimens gathered in the Mulgrave Wood, Yorkshire, in September, 1900, see *The Naturalist* (1901) 181. C.R.

become septate: there are no septate spores in my specimens. The ascospores are hyaline so that the brownish tinge of the spores examined by Massee was probably due, as he suggests, to the age of the specimen, or the poisoning for preservation. Currey does not give the habitat of the fungus, but Massee and Phillips record it as "on the ground"; these specimens were found growing on decaying wood.

*Chlorosplenium versiforme* (Pers.) de Not. This Discomycete also was taken in Horner Woods during the Minehead Foray. In my specimens the discs were of a bright olive green, not a dingy green as generally described, and this was due in great part to the green colour of the spores—a point certainly overlooked in the descriptions given by Massee, Phillips and Rehm who describe the spores as hyaline and colourless*. The paraphyses which Massee and Rehm describe as slender, thickened at the tips and yellowish brown were here slender and branched, green in colour and not thickened at the tips.

*Apostemidium vibrisseoides* (Pk.) Boud. I gathered this fungus several times growing on rotting branches of ash lying in the water courses of Horner Woods Easter 1920. The violent shooting out of the very long ascospores from the asci was a very conspicuous feature, and as Phillips so aptly describes for *Vibrissea truncorum* "many of them remain attached by one end to the hymenium waving to and fro like floss silk glittering in the light." I watched this happening using only a pocket lens as I carried the branches on which the fungus was growing shortly after lifting them out of the water course.

*Pachyella depressa* (Phill.) Boud. = ? *Humaria Oocardii* Sacc. In April 1920 in the Horner Woods I found a Mollisia like Discomycete on rotten wood, lying on very damp ground, which agreed in every respect with Phillips's description of *Pachyella depressa*, and although looking like a *Mollisia* externally had microscopic characters very unlike that genus. At the mycological foray Sept. 1920 I found in several places in the same woods a Discomycete which agreed with Karsten's description of *Humaria Oocardii* var. *ligniaria*. On looking up these fungi for their position in Ramsbottom's list of British Discomycetes I found the latter species put down as probably synonymous with the former: and on examining both collections again I found them similar in every respect except that the apothecia of those taken in the spring did not show the blue colouration with iodine which was very evident when those collected in the autumn were tested with the same reagent.

*Catinella olivacea* (Batsch) Boud. In August 1920 Dr W. T.

* Boudier Icones IV, 283, "Spores incolores ou à peine teintées." C.R.

Elliott gathered a very good specimen of this fungus in the Woods at Marston Green (Warwicks.).

Massee in a note appended to the description of this fungus considered that the spores which are described by Batsch, Currey and others as "with an olive or bluish-green tinge would, under normal conditions, be hyaline, the bluish or purplish tinge being a stain derived from the colouring matter present in the excipulum." In making this statement he is in error for the spores of the specimen I examined which was perfectly fresh and still growing were of a greyish black tint, and contained two guttulae, thus agreeing with the original description of Batsch.

The septate paraphyses described as colourless were tinged at the apex with a yellowish colour in my specimen. They were also branched, the apices often swelling out into a clavate head, measuring 9–10 × 4–5 $\mu$ and being continuous or septate. The rhizoids attaching the apothecium to the substratum of wood were a very conspicuous feature of the fungus.

*Orbilia flexuosa* Crossland. During the Baslow Foray 1919, I gathered in the Highlow Wood, a Discomycete which, with the exception of colour, agrees with the description of this species.

*O. flexuosa* is described by Crossland as pale reddish amber the colour changing to almost black when old and dry; my specimens were conspicuously pale beetroot colour when fresh with only a slight change to a darker tint for a long while, but after two years' drying many are almost black; also the apothecia are very regular in form in contrast to the tortuous lobed forms described by Crossland; however this tortuous lobing might be due to age.

Crossland describes the paraphyses "as numerous, filiform, very slightly or not at all thickened at the apex, which is tinted orange"; the paraphyses in my specimen agree as to form, but they are colourless; some are bent at the apex and all have oily contents. This fungus appears in Ramsbottom's list of British Discomycetes as a species of doubtful position. To judge from the paraphyses my specimen is certainly a *Hyalinia*.

*Mollisia caesia* (Fckl.) Sacc. During the Foray in the Wyre Forest, I found a good specimen of this beautiful Discomycete growing on a chip of oak. The subiculum on which the crowded apothecia were growing was quite well-formed and abundant*. This fungus is not common: I have only taken it once before in 1916 in Windmill Naps, Tanworth-in-Arden.

When quite young the apothecia are very hairy all over, but

* These specimens should be referred to *Trichopeziza caesia* (Pers.) Boud., see Hist. et Class. des Discomycètes d'Europe, 131. C.R.

on maturity each apothecium merely has round its base a dense halo of radiating hairs apparently tethering it down to the subiculum or substratum, for the subiculum tends to disappear in older specimens.

*Urceolella leuconica* (Cooke) Boud. I gathered in Ockeridge Woods during the Worcester Foray 1921, a fungus which agrees with the description of this fungus in all particulars, except that very delicate hyphae radiate from the apothecia attaching them to the substratum, and also some of the delicate hyphae extend and form a delicate cobweb-like subiculum: in this feature the fungus resembles *Hyaloscypha candidata* but yet the hairs on the margin and excipulum have the attenuated form characteristic of *U. leuconica*.

*Otidea violacea* A. L. Sm. and Ramsb. On October 22, 1921, Miss Olive Stansfield found in Clowes Wood, Earlswood Lakes, Warwicks., a specimen of this very beautiful amethyst Discomycete growing on burnt soil. This fungus was first described by Smith and Ramsbottom (Trans. Brit. Mycol. Soc. v, p. 237, 1915) from a specimen gathered in a garden near Warwick by Mr W. B. Grove, and in the main details the Earlswood specimen agrees with this with the exception of the asci which were only about 180 $\mu$ in length compared with 360 $\mu$ the length given for the Warwick specimen.

The paraphyses were hooked at the clavate ends, while those of the Warwick specimen are given as straight, this character being commented upon as one of the features distinguishing this species from *O. leporina*; the paraphyses also were sparingly septate and many showed dichotomy near their base: as is usual among Discomycetes the colouring matter in the paraphyses give the amethyst colour to the whole fungus.

In section the hypothecium is seen to be formed of a broad band of large, septate, irregularly inflated hyphae and a narrower band consisting of more regular hyphae forming a compact layer above the excipulum which also consists of large, septate, irregularly inflated hyphae which run out into irregular parenchymatous granulations on the exterior.

The inflated cells in the hypothecium often attained great dimensions, some measuring 60 × 35 $\mu$ or even 90 × 55 $\mu$. They very much resemble the water-storage cells found in many of the xerophytic higher plants; doubtless water-storage is their function here, these cells affording a reserve supply of water to be easily drawn upon by developing asci; but these inflated cells by changes in turgor probably play the part of motor cells, bringing about the closing or curling over movement of the walls of the apothecium during drought, and the opening out which follows on access to water again.

# NOTE.

## ON THE PARASITIC HABITS OF THE PLASMODIUM OF PHYSARUM VIRIDE VAR. RIGIDUM LISTER.

The following notes refer to the habitat of the plasmodium of *Physarum viride* var. *rigidum* as seen in tropical Malaya. Here this is one of the commonest and most widely distributed species, occurring especially on decaying logs of *Hevea brasiliensis*. My attention was first drawn to its possible parasitic nature by repeatedly finding the sporangia on or near the white fan-shaped pilei of *Schizophyllum commune*, the commonest of the Agaricineae found on dead Hevea; moreover the pilei on which sporangia occurred invariably presented a dried up, shrivelled, dead appearance. When the sporangia occurred on the bark of Hevea there were almost always masses of dead shrivelled Schizophyllum near by. That this appearance was not due to weather conditions was proved by the presence of other fresh growths of Schizophyllum on the same log; traces of the veins of the plasmodium could always be found on pilei bearing sporangia of the Physarum as well as on others free from sporangia in the immediate neighbourhood.

These field observations suggested an investigation into the habits of this plasmodium, and the following experiments were carried out.

Spores from freshly collected sporangia of the *Physarum* were sprinkled on damp fresh pilei of Schizophyllum gathered from a log showing no trace of Mycetozoa. In 48 hours yellow plasmodium was seen on the inoculated material kept in a damp chamber; most of the Schizophyllum was then still alive, as evidenced by the formation of new outgrowths at the bases of the stalks, but the parts of the upper surface of the pileus over which the plasmodium spread had turned a dirty brown. This change in colour and general appearance became more and more accentuated each succeeding 24 hours and by the sixth day all the Schizophyllum had been killed, the whole being then a dirty wet brown flaccid mass; from this the plasmodium was retiring and had begun to spread over the sides of the glass dish. Fresh pilei were placed in contact with the plasmodium, which in another 24 hours was spreading over the new food material. The plasmodium began to gather together into small masses preparatory to fruiting which took place the following day. The sporangia were at first yellow and remained so for some time. The final colour change occurred quickly, and almost simultaneously over the hundreds of sporangia, from a bright yellow to bronze brown. The final metallic bronzed appearance

was evident as soon as the whole was comparatively dry. During and immediately before the formation of capillitium and spores, there was no obvious evidence of extrusion of water, which is so notable a feature in the case of *Brefeldia maxima* (see Naturalist, July 1916), *Badhamia utricularis* and *Physarum nutans* in temperate regions. This may be due to the much higher temperature of South Malaya and the consequent more rapid evaporation from the outer surface of the sporangium walls.

In a further experiment a piece of Schizophyllum covered with plasmodium was removed and placed in contact with fresh *Hirneola hispida*. The rapid development of the plasmodium on the new host was extraordinary, for in 24 hours the whole surface of the Hirneola was covered with a dense network of plasmodium. The tissues of the fungus at the same time became so soft that it was impossible to lift it without breaking parts away. The plasmodium on this host assumed a lighter yellow colour and appeared more watery than on Schizophyllum.

Attempts to develop the plasmodium from spores sown on *Daldinea concentrica, Nummularia pithodes* and *Ustulina zonata* gave negative results, and portions of plasmodium transferred from Schizophyllum or from Hirneola to the above-named fungi all died.

A. R. SANDERSON.

## REVIEW.

*Lichens*. By Annie Lorrain Smith, F.L.S. Demy 8vo. Cloth, pp. 464. 135 figs. 55*s*. University Press, Cambridge.

The publication of "Lichens," the second volume of the Cambridge Botanical Handbooks, removes in a very efficient manner one of the bars to the study of Lichenology, viz. that caused by the lack of a comprehensive, readable, fully illustrated text-book on the subject. There is within its pages much valuable, well arranged, recent and interesting information respecting these puzzling plants that will appeal to the botanist, who is in no way a specialist, and who would fail to be attracted by a lichen flora in spite of all the skill that might be expended upon its production. At the same time it is a book that is essential to all serious students of Lichenology by reason of the very complete and exceedingly able treatment of the subject with which it deals.

The wide scope of Miss Smith's book is plainly evident in the tabulated list of its contents, which, arranged under numerous headings and in various forms of type, immediately follows the

preface. The exhaustive bibliography of books and papers, all of which are cited in the text, also bears witness to the comprehensiveness of the volume.

It is in the preface that Miss Smith expresses an opinion that her method has somewhat overburdened the pages with citations, but it is more than probable that the student will regard this important feature of her book as a veritable mine of wealth.

In the pages of the introduction (pp. xxiii to xxviii) the author expresses a definite view, which one would expect, regarding the relation of fungus and alga as it exists in the lichen thallus. It is that "Each symbiont contributes in varying degree to the common support," but, there is clear evidence throughout the book that no attempt is made unduly to press the writer's personal opinion.

One of the most ably written chapters is that on phylogeny, a subject that is admittedly difficult to write about in clear and simple language, but Miss Smith does so without overburdening the chapter with unnecessary technicalities and in such a manner that the argument can be followed by the botanist who has no special knowledge of systematic lichenology.

The chapter devoted to Ecology gives a resumé of the present knowledge of the ecology of lichens arranged under appropriate headings. Numerous citations are given. Whether the papers referred to have been of the kind that add to the data already accumulated, or of those that theorise on what is already known, all have received recognition.

The illustrations, 315 in number (some of which are line block and others process reproduction of photographs) have not always the merit that one expects to find in a book of this class. The most favourable position for an illustration is by the printed matter that it is intended to illustrate, but this juxtaposition should not be made when the paper of the book proves unsuitable, as it certainly does, in this case, for process work. The appearance of the book would have been greatly enhanced had the photographs, on suitable paper, been inserted at the end of each chapter.

It is cause for regret that the book, which at once proves itself to be indispensable to all lichenologists, could not be produced at a much lower price than that at which it is published.

This volume together with the Monograph of British Lichens (two volumes) gives a fuller perspective of the important and laborious work that was undertaken by Miss Smith. One becomes more fully aware of the firm grip and the discriminating critical knowledge that have been exercised in the writing of this trilogy, and the writer is to be heartily congratulated on the completion of this part of her work.

R. P.

## LIST OF MEMBERS.

### *Honorary Members.*

Bresadola, L'Abbé G., Via Cr. Madruzzo 17, Trento, Italia (1921).
Patouillard, Dr N., 105, Avenue du Roule, Neuilly-sur-Seine (Seine), France (1920).
Rea, Mr Carleton, B.C.L., M.A., 6, Barbourne Terrace, Worcester (1918).
Thaxter, Professor Roland, 7, Scott Street, Cambridge, Mass., U.S.A. (1920).

### *Ordinary Members.*

1. Aberdeen, The University Library (1916).
2. Adams, Mr J. H., Great Bedwyn, Hungerford, Wilts. (1919).
3. Adcock, Mr Archie, Upton Road, Norwich (1921).
4. Alcock, Mrs N. L., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919).
5. Alexander, Rev. Philip J., C.J., St George's College, Weybridge (1921).
6. Allen, Mr W. B., Benthall, Broseley, Salop (1902).
7. Bagchee, Mr K., Imperial College of Science, South Kensington, London, S.W. 7 (1920).
8. Baghdad, Director of Agriculture, New Street, Baghdad (1920).
9. Barnett, Miss E. C., Botany Department, Marischal College, Aberdeen (1921).
10. Barr, Rev. Robert, The Manse, Neilston, Renfrewshire (1918).
11. Barrington, Dr F. J. F., University College Hospital Medical School, University Street, London, W.C. 1 (1901).
12. Bartlett, Mr A. W., M.A., B.Sc., Dept. of Botany, Armstrong College, Newcastle-upon-Tyne (1920).
13. Batten, Dr L., Birkbeck College, Breams Buildings, Chancery Lane, London, W.C. 2 (1921).
14. Baxter, Mr W. H., 19, Ashton Terrace, Hillhead, Glasgow (1919).
15. Bayliss, Miss Jessie Sproat, D.Sc. (*see* Mrs J. S. Bayliss Elliott) (1911).
16. Beer, Mr Rudolph, B.Sc., F.L.S., Westwood, Bickley, Kent (1919).
17. Bellerby, Mr William, 8, Burton-Stone Lane, York (1917).
18. Biffen, Professor R. H., M.A., F.R.S., 136, Huntingdon Road, Cambridge (1899).

19. Bintner, Mr Jean, Ingénieur Horticole, Helmdange, Gr. Duché de Luxembourg (1919).
20. Birmingham Natural History and Philosophical Society, c/o W. E. Groves, Esq., 21, Vicarage Road, Edgbaston, Birmingham (1920).
21. Bisby, Dr G. R., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey (1921).
22. Blackman, Professor V. H., F.R.S., M.A., Imperial College of Science, South Kensington, London, S.W. 7 (1900).
23. Blackwell, Miss E. M., M.Sc., Hartley Botanical Laboratories, The University, Liverpool (1917).
24. Blagden, Mr Charles Otto, 57, Earl's Court Square, London, S.W. 5 (1910).
25. Bloom, Rev. James Harvey, 601, Bank Chambers, 329, High Holborn, London, W.C. 1 (1915).
26. Borthwick, Dr A. W., O.B.E., Royal Botanic Garden, Edinburgh (1911).
27. Bose, Professor S. R., Carmichael Medical College, Belgachia, Calcutta, India (1921).
28. Boston, The Mycological Club, c/o Miss Jessie F. Conant, 26, Prospect Street, Melrose, Mass., U.S.A. (1900).
29. Bourdot, L'Abbé H., St Priest en Murat, par Montmarault, Allier, France (1921).
30. Boyd, Mr D. A., St Clair, Caledonia Road, Saltcoats, N.B. (1906).
31. Brazier, Mr E., Brook Road, Old Swinford, Stourbridge (1921).
32. Brett, Miss M., B.Sc., Northern Polytechnic, Holloway Road, London, N. 5 (1921).
33. Brierley, Dr W. B., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919).
34. British Museum, The Trustees of, Cromwell Road, London, S.W. 7 (1914).
35. Brooks, Mr F. T., M.A., The Botany School, Cambridge (1907).
36. Brooks, Dr St John, Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
37. Brown University, East Side Station, Providence, R.I., U.S.A., Library (1920).
38. Bruxelles, Jardin Botanique de l'Etat (1911).
39. Bryce, Mr G., B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon (1915).
40. Buckley, Mr W. D., 8, Victoria Street, Slough (1916).
41. Buddin, Mr Walter, M.A., Laboratory for Plant Pathology, University College, Reading (1921).
42. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.C.S., University of Manitoba, Winnipeg, Canada (1911).

43. Bunting, Mr R. H., Agricultural Department, Aburi, Gold Coast Colony (1921).
44. Bunyard, Capt. G. N., 25, Bower Mount Road, Maidstone (1920).
45. Butcher, Mr R. W., Botanical Dept., The University, Leeds, and 95, Middleton Hall Road, King's Norton, Birmingham (1921).
46. Butler, Dr E. J., C.I.E., M.B., Imperial Bureau of Mycology, 17, Kew Green, Surrey (1920).
47. Cadman, Miss E. J., Imperial College of Science, South Kensington, London, S.W. 7 (1921).
48. Calcutta Museum, Professor of Botany, Biological Library, 35, Ballygunge Circular Road, Calcutta, India (1921).
49. Calder, Mr Ronald B., B.A. (Cantab.), B.Sc., East London College, Mile End Road, London, E. 1 (1920).
50. Cambridge, The Botany School (1920).
51. Carr, Professor J. W., M.A., University College, Nottingham (1896).
52. Cartwright, Mr K. St S., Rothbury, Hay, Hereford (1913).
53. Cayley, Miss D. H., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey (1913).
54. Chaudhuri, Mr H., Imperial College of Science, South Kensington, London, S.W. 7 (1920).
55. Cheel, Mr Edwin, Botanic Gardens, Sydney, N.S.W., Australia (1919).
56. Cheesman, Mr W. N., J.P., The Crescent, Selby (1896).
57. Chicago, The Library, University of Illinois, U.S.A. (1914).
58. Chipp, Mr T. F., B.Sc., F.L.S., Forestry Dept., Coomassie, Gold Coast (1919).
59. Clarke, Miss H., M.Sc., 45, Beaconsfield Road, Seaforth, Liverpool (1917).
60. Clarke, Mr James Jackson, 25, Norfolk Road, London, N.W. 8 (1920).
61. Cleland, Dr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia (1918).
62. Coimbatore, The Librarian, College of Agricultural Research, Lawley Road, P.O., Coimbatore, Madras (1918).
63. Collett, Mr R. Leslie, M.A., Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
64. Collins, Miss Florence, The School of Gardening, Clapham, near Worthing, Sussex (1920).
65. Cooper, Miss C. A., Hillside Cottage, California Road, Bushey Heath, Herts. (1911).
66. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y. (1920).

67. Corner, Mr E. M., Woodlands Park, Great Missenden, Bucks. (1920).
68. Cotton, Mr A. D., F.L.S., Herbarium, Royal Botanic Gardens, Kew (1902).
69. Crow, Mr W. B., M.Sc., F.L.S., University College of South Wales and Monmouthshire, Cardiff (1921).
70. Curtis, Miss Kathleen M., M.A., M.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand (1917).
71. Cutting, Mr E. M., M.A., F.L.S., Botanical Dept., University College, Gower Street, London, W.C. 1 (1920).
72. Darbishire, Professor O. V., B.A., Ph.D., The University, Bristol (1913).
73. Dastur, Mr J. F., Imperial Agricultural Research Institute, Pusa, Bihar, India (1920).
74. Davis, Dr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wisconsin, U.S.A. (1921).
75. Day, Mr E. Metcalfe, Rowan Cottage, Minchinhampton, Glos. (1921).
76. Dickinson, Mr S., Imperial College Union, South Kensington, London, S.W. 7 (1921).
77. Dowson, Mr W. J., M.A., F.L.S., R.H.S. Gardens, Wisley, Surrey (1920).
78. Drinkwater, Mr Harry, M.D., M.R.C.S., F.L.S., J.P., etc., Lister Lodge, Wrexham (1910).
79. Ealand, Mr C. A., 32, Hamlet Gardens, Ravenscourt Park, London, W. 6 (1921).
80. Edwards, Mr W. H., Curator, The Museum, Birmingham (1896).
81.* Elliott, Mrs J. S. Bayliss, Arden Grange, Tanworth in Arden, Warwickshire (1911).
81. Elliott, Dr W. T., L.D.S., R.C.S., F.Z.S., Arden Grange, Tanworth in Arden, Warwickshire (1911).
82. Else, Mr W. J., 6 *a*, Britannia Square, Worcester (1921).
83. Essex Field Club, c/o Percy Thompson, Esq., F.L.S., Essex Museum of Natural History, Romford Road, Stratford, Essex, E. 15 (1919).
84. Evans, Mr William, F.R.S.E., 38, Morningside Park, Edinburgh (1911).
85. Eyre, Miss J. C., Ippelpen, Newton Abbot, Devon (1915).
86. Fenton, Mr E. W., Botanical Department, Seale-Hayne, Agricultural College, Newton Abbot, Devon (1920).
87. Finlayson, Mr Raymond A., F.L.S., The Parsonage Farm, Downton, Wilts. (1910).

88. FitzGerald, Rev. H. P., F.L.S., Lidwells, Goudhurst S.O., Kent (1896).
89. Franklin, The Hon. Mrs, Glenalla, Ray, Letterkenny, co. Donegal (1919).
90. Fraser, Miss H. C. I. (*see* Prof. Dame Helen Gwynne-Vaughan).
91. Fynes-Clinton, Rev. C. E., M.A., St James's Vicarage, Leyland, Preston (1917).
92. Gadd, Mr C. H., Royal Botanic Gardens, Peradeniya, Ceylon (1921).
93. Gardner, Capt. Frederic, c/o Lloyd's Bank, Jersey, C.I. (1898).
94. Gates, Professor R. R., B.Sc., Ph.D., King's College, Strand, London, W.C. 2 (1921).
95. Gilchrist, Miss Grace G., B.Sc., Botanical Dept., The University, Bristol (1921).
96. Goodwin, Mr D. P., Oakden, Kidderminster (1902).
97. Gould, Mr F. G., Elmhurst, Church Hill, Loughton, Essex (1918).
98. Green, Col. C. Theodore, A.M.S., M.R.C.S. (Eng.), L.R.C.P. (Lond.), F.L.S., 31, Shrewsbury Road, Birkenhead (1901).
99. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey (1917).
100. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, S.E. 18 (1913).
100.* Gwynne-Vaughan, Professor Dame Helen, D.B.E., D.Sc., LL.D., etc., 93, Bedford Court Mansions, London, W.C. 1 (1906).
101. Haas, Dr P., University College, Gower Street, London, W.C. 1 (1921).
102. Hadden, Mr Norman G., Breezy Bank, West Porlock, Somerset (1911).
103. Hansford, Mr C. J., Microbiologist, Dept. of Agriculture, Jamaica (1921).
104. Harrison, Mrs E., 11, Grosvenor Avenue, West Kirby, Cheshire (1913).
105. Harrison, Mr H. W., 11, Grosvenor Avenue, West Kirby, Cheshire (1913).
106. Harvey, Mrs Cecily D., Barwick in Elmet Rectory, near Leeds (1910).
107. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1 (1913).
108. Hawley, Sir H. C., The Manor House, Lytchett Matravers, Poole, Dorset (1907).
109. Hildyard, Mr F. W., 14, Lambridge, Bath (1913).

110. Hiley, Mr Wilfred E., M.A., Research Institute, School of Forestry, Oxford (1913).
111. Holmes, Mr E. Morell, F.L.S., F.R.H.S., Ruthven, Sevenoaks, Kent (1906).
112. Holt, Mr W. H., 17, Ashville Road, Birkenhead (1914).
113. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii (1920).
114. Horne, Dr A. S., Botanical Dept. Imperial College of Science, South Kensington, London, W. 7 (1921).
115. Howard, Mr H. J., F.R.M.S., 6, College Road, Norwich (1918).
116. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898).
117. Humphrey, Mr C. J., Laboratory of Forest Pathology, Old Soils Building, University of Wisconsin, Madison, Wisconsin, U.S.A. (1921).
118. Hunter, Mr C., M.Sc., Botanical Dept., The University, Bristol (1921).
119. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth (1921).
120. Illinois, The Library, University of, Urbana, Illinois, U.S.A. (1920).
121. Jack, Mr H. W., B.Sc., B.A., Economic Botanist, Dept. of Agriculture, Kuala Lumpur, Federated Malay States (1913).
122. Jewson, Miss Sybil T., B.Sc., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919).
123. Johnson, Mr J. W. Haigh, M.Sc., F.L.S., Walton, near Wakefield (1919).
124. Johnstone, Mr R. B., 134, Cambridge Drive, Glasgow (1908).
125. Jones, Mr Robert Fowler, Austral House, Woodhall Spa, Lincolnshire (1918).
126. Keef, Miss Phoebe, Mortimer Lodge, Wimbledon Park, London, S.W. 17 (1921).
127. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921).
128. Kendall, Miss O., Pathological Laboratory, Milton Road, Harpenden, Herts. (1921).
129. Kew, The Library, Royal Botanic Gardens (1921).
129.* Kidd, Mrs Franklin, The Botany School, Cambridge (1919).
130. Knight, Mr H. H., M.A., The Lodge, All Saints Villas, Cheltenham (1914).
131. Krieger, Mr L. C. C., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921).

132. Line, Mr James, M.A., School of Agriculture, Cambridge (1921).
133. Linnean Society, Burlington House, Piccadilly, London, W. 1 (1919).
134. Lister, Mr A. B., D.I.C., B.Sc.(Lond.), Experimental and Research Station, Turner's Hill, Cheshunt, Waltham Cross, Herts. (1916).
135. Lister, Miss Gulielma, F.L.S., Leytonstone, Essex, and Highcliff, Lyme Regis (1903).
136. Lloyd, Mr C. G., The Lloyd Library and Museum, 224, West Court Street, Cincinnati, Ohio, U.S.A. (1907).
137. MacCallum, Dr B. D., M.A., D.Sc., F.L.S. Royal Botanic Gardens, Edinburgh (1921).
138. Macfie, Dr J. W. Scott, M.A., D.Sc., 21*a*, Alfred Street, Liverpool (1900).
139. Mackenzie, Miss A. D., Ministry of Agriculture, 4, Whitehall Place, London, S.W. 1 (1921).
140. Mackenzie, Mr D. Afton, Busby, N.B. (1900).
141. Main, Mr Robert, 1, Rosslyn Avenue, Low Fell, Gateshead (1918).
142. Maire, Dr René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algers (1907).
143. Maitland, Mr T. D., Government Botanist, Dept. of Agriculture, Kampala, Uganda (1916).
144. Marmont, Mr Basil P., Windsoredge House, Inchbrook, near Woodchester, Glos. (1908).
145. Marriott, Mr St John, 37, Owenite Street, Abbey Wood, London, S.E 2. (1920).
146. Marshall, Mr A., 21, Potter's Hill, Aston, Birmingham (1921).
147. Mason, Mr E. W., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey (1921).
148. Mason, Mr F. A., F.R.M.S., M.S.P.A., The Laboratory, 3, Queen's Square, Leeds (1912).
149. Mason, Mr F. R., Assistant Mycologist, Dept. of Agriculture, Kuala Lumpur, Federated Malay States (1921).
150. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh (1921).
151. McCutcheon, Mr William, B.A., B.Sc., Goulburn, 89, Argyle Road, Saltcoats, N.B. (1920).
152. McDougall, Professor W. B., University of Illinois, Urbana, Illinois, U.S.A. (1921).
153. Mehta, Professor K. C., The Botany School, Cambridge (1921).

154. Melbourne, The Director, Department of Agriculture, Science Branch, 605, Flinders Street, Melbourne, Australia (1921).
155. Menzies, Mr James, 117, Scott Street, Perth (1917).
156. Meulenbroff, Dr J. S., President Dutch Mycological Society, Zwolle, Holland (1921).
157. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902).
158. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan (1919).
159. Montague, Mrs A. Penton, Crediton, N. Devon (1898).
160. Morris, Mr T. N., B.A., Dip. Agr. (Cantab.), St John's College, Cambridge (1919).
161. Mounce, Miss Irene, M.A., Botanical Dept., University of Manitoba, Winnipeg, Canada (1921).
162. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea (1921).
163. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Bennekom, Holland (1920).
164. Newcastle-upon-Tyne Literary and Philosophical Society (1902).
165. Newman, Mr Leslie F., M.A., F.L.S., Dip. Agr. (Cantab)., St Catharine's College, Cambridge (1906).
166. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904).
167. Nicholson, Mr Charles, F.E.S., 35, The Avenue, Hale End, Chingford (1916).
168. Nicholson, W. E., Lewes (1913).
169. Noel, Miss E. F., F.L.S., 37, Moscow Court, London, W. 2 (1913).
170. North Carolina, University of, Chapel Hill, N.C., U.S.A. (1920).
171. Ogle, Mr B. S., Hill House, Steeple Aston, Oxon. (1904).
172. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove (1908).
173. O'Loughlin, Miss Bessie, Rocklands, Wallasey, Cheshire (1913).
174. Ontario Agricultural College Library, Guelph, Ontario, Canada (1920).
175. Osborn, Professor T. G. B., M.Sc., Professor of Botany, Adelaide University, South Australia (1910).
176. Overeem, Mr C. Van, Mycological Museum, Weesp, Holland (1920).
177. Overton, Mr H., A.C.A., Newlands, Boswell Road, Sutton Coldfield, Birmingham (1920).
178. Owen, Miss M. Nest (*see* Mrs Franklin Kidd), (1919).

179. Page, Miss W. M., B.Sc., Birkbeck College, Breams Buildings, Chancery Lane, London, W.C. 2 (1921).
180. Parke, Davis and Co., Librarian, Research Dept., Detroit, Mich., U.S.A. (1920).
181. Paul, The Very Rev. David, LL.D., D.D., 53, Fountainhall Road, Edinburgh (1899).
182. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex (1918).
183. Peacock, Dr H. G., Hareston Lodge, Torquay (1896).
184. Pearson, Mr A. A., F.L.S., 59, Southwark Street, London, S.E. 1 (1911).
185. Peck, Mr A. E., Tosti, 20, Avenue Road, Scarborough (1918).
186. Peltereau, Monsieur E., Notaire honoraire, Vendôme, Loir et Cher, France (1909).
187. Perthshire Society of Natural Science, c/o James Winter (Hon. Treas.), 35, George Street, Perth (1919).
188. Petch, Mr T., B.A., B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon (1911).
189. Pethybridge, Dr G. H., B.Sc., Dept. of Agriculture and Technical Instruction for Ireland, Royal College of Science, Upper Merrion Street, Dublin (1919).
190. Phillips, Mr J. F., King William's Town, South Africa, c/o Nicol, 23, Marchmont Crescent, Edinburgh (1921).
191. Phillips, Professor Reginald W., M.A., D.Sc., F.L.S., Professor of Botany, University College of North Wales, Bangor (1911).
192. Plowright, Mr C. T. P., B.A., M.B., King Street, King's Lynn (1901).
193. Potter, Rev. Professor M. C., Sc.D., M.A., F.L.S., Armstrong College, Newcastle-upon-Tyne (1896).
194. Potts, Mr George, Benthall House, Broseley, Salop (1910).
195. Priestley, Professor J. H., B.Sc., F.L.S., Botanical Dept., University of Leeds (1912).
196. Priestley, Mrs Marion E., 10, Monk Bridge Road, Headingley, Leeds (1919).
197. Pusa, Imperial Mycologist (1921).
198. Ramsbottom, Mr J., M.A., F.L.S., O.B.E., British Museum, Cromwell Road, London, S.W. 7 (1910).
199. Ramsbottom, Mr J. K., c/o Geo. Munro, Ltd., 4, Tavistock Street, Covent Garden, London, W.C. 2 (1914).
200. Rayner, Mr J. F., Swaythling, Southampton (1902).
201. Rayner, Dr M. C., Bedford College, Regent's Park, London, N.W. 1 (1921).
202. Rea, Mrs E. A., 6, Barbourne Terrace, Worcester (1896).

203. Rea, Miss M. W., Salem House, Sydenham, Belfast, Ireland (1920).
204. Rea, Miss Violet, 6, Barbourne Terrace, Worcester (1921).
205. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1 (1921).
206. Rhymes, Mr Charles, High Bois, Chesham, Bucks. (1921).
207. Richards, Mr R. M., A.R.C.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements (1915).
208. Ridler, Miss W. F. F., B.Sc., Botanical Dept., The University, Bristol (1921).
209. Roberts, Mrs A. W. Rymer, The Common, Windermere (1920).
210. Robson, Mr R., M.Sc., F.Z.S., Writtle, Chelmsford, Essex (1914).
211. Roper, Miss I. M., 4, Woodford Road, Redland, Bristol (1921).
212. Rushton, Mr W., A.R.C.S., D.I.C., St Mary's Hospital, Medical School, Paddington, London (1914).
213. St Paul, Minn., U.S.A., The Library, Dept. of Agriculture, University Farm (1920).
214. Salisbury, Dr E. J., F.L.S., University College, Gower Street, London, W.C. 1 (1921).
215. Sampson, Miss K., B.Sc., Economic Botanist, Plant Breeding Station for Wales, University College, Aberystwith (1920).
216. Sanderson, Mr A. R., F.L.S., Research Laboratory, Petaling, Federated Malay States (1921).
217. Schinz, Professor Dr Hans, Botanical Garden, Zurich (1921).
218. Scott, Mr W. Murray, Wakemills, Haslemere, Surrey (1921).
219. Searle, Mr G. Odell, B.Sc., Agric. (Lond.), Research Botanist, Linen Industry Research Association, Glenmore House, Lambeg, Lisburn, Ireland (1920).
220. Selborne Society, 42, Bloomsbury Square, London, W.C. 1 (1913).
221. Sharpe, Mr C. J., Brambleside, Manor Road, Sidcup (1905).
222. Shaw, Dr F. J. F., B.Sc., F.L.S., Imperial Agricultural Research Institute, Pusa Bihar, India (1920).
223. Small, Mr W., M.B.E., M.A., B.Sc., Mycologist, Dept. of Agriculture, Kampala, Uganda (1915).
224. Smith, Miss Annie Lorrain, F.L.S., 20, Talgarth Road, West Kensington, London, W. 14 (1899).
225. Smith, Miss K. E., 64, Coton Road, Nuneaton (1913).
226. Smith, Mr Thomas, 25, Lyme Street, Stockport (1918).

227. South London Botanical Institute, Tulse Hill, Herne Hill, S.E. 24 (1921).
228. Stationary Office, H.M., Superintendent of Publications, Book Dept., Westminster, S.W. 1 (1920).
229. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., 10, Bank Parade, Preston (1914).
230. Swanton, Mr E. W., A.L.S., Brockton, Haslemere, Surrey (1899).
231. Swedish Academy of Sciences, Royal (1919).
232. Tabor, Mr Richard John, B.Sc., F.L.S., Imperial College of Science, South Kensington, London, S.W. 7 (1914).
233. Tagg, Mr H. F., F.L.S., Royal Botanic Gardens, Edinburgh (1921).
234. Tatum, Mr E. J., Salisbury (1896).
235. Taylor, Miss B. K., 98, Cheyne Walk, Chelsea, London, S.W. 3 (1910).
236. Temperley, Mr Nicholas, 4, Carlton Terrace, Low Fell, Gateshead-on-Tyne (1918).
237. Thomas, Mr H. Hamshaw, M.B.E., M.A., The Botany School, Cambridge (1910).
238. Thomson, Miss Mary R. H., c/o The Chief, Division of Botany, Box 994, Pretoria (1917).
239. Toronto, University of, Librarian, Toronto, Canada (1919).
240. Tothill, Dr Vincent, c/o Trinidad Leaseholds, Ltd., Norme l'Enfer Forest Reserve, Fyzabad, Trinidad, B.W.I. (1912).
241. United States Dept. of Agriculture (1907).
242. Vines, Professor S. H., M.A., D.Sc., F.R.S., Langstone, Exmouth, Devon (1915).
243. Wager, Dr Harold, F.R.S., F.L.S., 4, Bank View, Chapel Allerton, Leeds (1896).
244. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew (1911).
245. Wallis, Mr A. Westacre, Station Road, Kettering (1921).
246. West Indies, Commissioner of Agriculture for, Imperial Dept. of Agriculture, Barbados, B.W.I. (1921).
247. Wheldon, Mr H. J. (1918).
248. Whetzel, Professor H. H., Professor of Plant Pathology, New York, State College of Agriculture, Cornell University, Ithaca, N.Y., U.S.A. (1914).
249. Whitaker, Mr F. Owen, 89, Eccleston Square, London, S.W. 1 (1921).
250. Whitehead, Mr T., University College of North Wales, Bangor (1920).
251. Williams, Professor J. Lloyd, D.Sc., F.L.S., University College of North Wales, Bangor (1921).

252. Williamson, Mrs H. S., Imperial College of Science, South Kensington, London, S.W. 7 (1921).
253. Wilmott, Mr A. J., B.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7 (1921).
254. Wilson, Mr A. E., Southey House, College Green, Bristol (1920).
255. Wilson, Dr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh (1912).
256. Wiltshire, Mr S. P., Research Station, Long Ashton, Bristol (1920).
257. Woolhope, The Naturalists' Field Club, c/o C. S. Scobie, 2, Offa Street, Hereford (1896).
258. Worcestershire Naturalists' Field Club, c/o F. T. Spackman, Esq., F.G.S., 190, Bath Road, Worcester (1921).
259. Wormald, Dr H., South Eastern Agricultural College, Wye, Kent (1921).

## RULES.

*Society's name and objects.*

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

*Members of Society.*

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

*Honorary Members.*

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

*Foundation Members.*

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

*Officers.*

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

*Government of Society.*

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct., 1903.

*Period of Office.*

7. The Officers and Council shall hold office as from the 1st of January following their election.

*Election of Members.*

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

*Subscription.*

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

*Meetings.*

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

*Accounts.*

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

*Alteration of Rules.*

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

# APPENDIX.

*Form of proposal for Ordinary Membership of the British Mycological Society.*

.....

*of* .....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

*Certificate to be signed by the Candidate.*

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

# INDEX.


Abies pectinata, 221
Achillea Millefolium, 81
Acremonium araucanum, 36
Acrostalagmus coccidicola, 36
Aecidium Orchidearum, 82, 83
— Prunellae, 83
Aegerita candida, 54
— Webberi, 36
Aira caespitosa, 82
Alder stick, 57
Alternaria, 173, 181
Alwisia Bombarda, 249, 253, 255
Anchusa arvensis, 82
Androsaceus Hudsonii, 3
Anthoxanthum odoratum, 83
Apostemidium vibrisseoides, 296
Arachnopeziza aurata, 293, text-fig. 1, 294
Arcyria cinerea, 13, 250, 251, 254, 255
— denudata, 11, 13, 242, 250, 254, 255
— ferruginea, 250, 254, 255
— insignis, 250, 254, 255
— nutans, 250, 254, 255
— Oerstedtii, 12, 13, 254
— virescens, 250, 254, 255
Aschersonia Aleyrodis, 29, 37, 39
— basicystis, 31
— Coffeae, 29, 32
— confluens, 29
— cubensis, 29
— Goldiana, 38
— guianensis, 30
— Henningsii, 23, 100, 157, 164
— hypocreoidea, 29
— marginata, 29, 32
— oxyspora, 30, 31
— oxystoma, 37
— placenta, 29, 31, 37
— samoensis, 29
— taitensis, 30, 31
— turbinata, 29, 31
Ascobolus magnificus, 268
Ascochyta citrullina, 173
— Lycopersici, 191
— Pisi, 174
Ascocorticium, 60
— albidum, 60
— anomalum, 60
Ascomyces anomalus, 60
Ascophanus cervarius, 1, 59
Atractium ciliatum, 115
— coccigena, 120, 123
— flammeum, 20, 21, 91, 96, 115, 117, 118, 119, 159, 163
— gelatinosum, 115
— minor, 117, 118, 119
— pallidum, 118
Atractium stilbaster, 115
— Therryanum, 115

Bacterium vermiforme, 87
Badhamia affinis, 15, 243, 253, 254
— nitens, 15
— orbiculata, 243, 251, 253, 254
— reticulata, 15
— utricularis, 246, 300
Balm of Gilead, 86
Beech log, 56
Bees, Belgian, 86
— Californian, 86
— Egyptian, 86
— Mesopotamian, 86
— Palestine, 86
— Water, 86
— Wine, 86
Belonidium deparculum, 60
Berberis arcuata, 2
Birch bark, 57
Blue-rot, 231, 232
Boletus scaber, 278, 279
Botrytis cinerea, 85
— Douglasii, 85
Bourdot, L'Abbé H., "Two New Basidiomycetes," 50
Brefeldia maxima, 300
Brooks, F. T., M.A., "An investigation of some Tomato diseases," 173
— "The inheritance of disease-resistance in plants," 71
Brooks, R. St John, M.D., D.P.H., M.A, "The National Collection of type cultures," 237
Broomella Ichnaspidis, 27, 94, 95, 153, 163
— major, 153, 163
Brunella vulgaris, 83
Buller, A. H. R., D.Sc., Ph.D., F.R.C.S., "On the audibility of the 'puffing' in the larger Discomycetes," 4
— "Slugs as mycophagists," 270
— "The basidial and oidial fruit-bodies of *Dacryomyces deliquescens*," 226
— "Upon the ocellus function of the subsporangial swelling of *Pilobolus*," 61
Butler, E. J., C.I.E., D.Sc., M.B., F.L.S., "The Imperial bureau of mycology," 168

Calonectria coccidophaga, 96, 141, 153, 161, 165, Pl. IV, figs. 3–4, Pl. V, fig. 7
Catinella olivacea, 296

Cephalosporium, 283
— Lecanii, 36, 37, 39
Ceratiomyxa flexuosa, 243, 253, 254
— fruticulosa, 243, 253, 254
Ceratostoma piliferum, 231
Ceratostomella cana, 231
— coerulea, 231
— Piceae, 231, 232, 233, 235, 236, Pl. VIII, figs. 2–7
— pilifera, 231, 232
— Pini, 231, 232, 233
Chionaspis salicis, 1
Chlorella, 45
— miniata, 45
— vulgaris, 43, 44
Chlorosplenium versiforme, 1, 296
Cienkowskia reticulata, 247, 253, 254
Cladonia digitata, Pl. I, fig. 6
Cladosporium, 233
— fumago, 217, 218
Clathrus cancellatus, 3
Clavaria luteoalba, 1
— stricta, 2
Cnicus arvensis, 59
Coccidophthora variabilis, 24, 95
Colletotrichum phomoides, 173, 194, 196
Collett, R. Leslie, "Longevity of spores of a fungus in a museum specimen," 217
Colloderma oculatum, 11, 15
Comatricha elegans, 15
— irregularis, 248, 253, 255
— laxa, 247, 253, 255
— longa, 248, 253, 255
— pulchella, 247, 250, 253, 255
— tenerrima, 14
— typhoides, 248, 253, 255
Coniophorella olivacea, 50
Coprinus comatus, 211, 215
— cordisporus, 210, 211, 215
— curtus, 210, 211, 215, Pl. VI, fig. 13
— ephemeroides, 213
— ephemerus, 210, 213, 215, Pl. VI, fig. 12
— fimetarius, 198, 207, 213, 256, 258, 261, 268
— flocculosus, 1
— lagopus, 205, 213, 215, 216, Pl. VI, figs. 5–8, Pl. VII, fig. 2, 256, 257, 258, 259, 260, 261, 262, 263, 264, 266, 267, 268, 269
— niveus, 209, 213, 214, 215, 216, Pl. VI, figs. 10–11, 256, 257, 258, 259, 265, 266, 267, 268, 269
— picaceus, 1
— stellatus, 201, 210, 211, 215
— stercorarius, 207, 213, 215, Pl. VI, fig. 9, 256, 257, 260, 266, 269
— sterquilinus, 203, 213, 214, 215, Pl. VI, figs. 1–4, Pl. VII, fig. 1, 256, 257, 259, 260, 266, 269
Corallomyces, 113, 114, 115
— aurantiicola, 158
— elegans, 113
— flammea, 114
— repens, 114
Cordyceps, 27
— clavulata, 28
— coccigena, 28
— dipterigena, 28
— pistillariaeformis, 27, 28, 40
Corticium filicinum, 51
— lividum, 50
— Pearsonii, 51, and text-fig. 1, 52
— rubropallens, 50
— sphaerosporum, 56
— submutabile, 56
Cortinarius caninus, 278, 279, 280, 281
Council, 1
Craterium minutum, 14, 247, 253, 255
Creonectria, 133
Cribraria aurantiaca, 13
— dictydioides, 253, 255
— intricata, 246, 248, 253, 255
— microcarpa, 253, 255
— notabilis, 12
— pyriformis, 12, 13
— splendens, 255
— violacea, 248, 253, 255
Cronartium ribicola, 83
Cyphella alboviolascens, 1
Cystococcus, 44
Cytotriplospora, 47
— Pini, 47 and text-fig. 48

Dacryomyces deliquescens, 226, 228, 230
— stillatus, 226, 229, 230
Daisies, Michaelmas, 283
Dasyscypha calyciformis, 79
— crystallina, 59
— diplocarpa, 295, text-fig. 2, 295
— subtilissima, 79
Diachaea cerifera, 15
— leucopoda, 247, 253, 255
Dialonectria coccicola, 161
Dianema corticatum, 15
Dictydiaethalium plumbeum, 249, 253, 255
Dictydium cancellatum, 11, 13, 248, 253, 255
Diderma arboreum, 247, 253, 255
— effusum, 11, 247, 253, 255
— hemisphericum, 247, 253, 255
— ochraceum, 14
Didymium Clavus, 14, 247, 253, 255
— dubium, 10
— leoninum, 253, 255
— nigripes, 247, 253, 255
Diplodina citrullina, 175, 189
— destructiva, 175, 196
— Lycopersici, 191, 192, 196
Discofusarium, 25, 143, 164

Discofusarium Mytilaspidis, Pl. V, fig. 13
— tasmaniense, 25, 143, 161, 165, Pl. IV, figs. 1–2, Pl. V, fig. 13
Disease-resistance in plants, Inheritance of, 71
Dowson, W. J., M.A., F.L.S., "On the symptoms of wilting of Michaelmas Daisies produced by a toxin secreted by a Cephalosporium," 283
Dung, red deer, 1, 59
Duplicaria Empetri, 85

Elliott, J. S. Bayliss, D.Sc., "Studies in Discomycetes III," 293
— "Three Fungi Imperfecti," 47
Empetrum nigrum, 84
Empusa Lecanii, 34
Endoconidiophora coerulescens, 231
Endothia Passeriniana, 121
Enerthenema papillatum, 15
Enteridium olivaceum, 12, 13
Enterographa crassa, 16
Entomogenous fungi, Studies in, 89
Eremascus albus, 293, 294
Erionema aureum, 245, 253, 254
Erysiphe graminis, 76
Evernia prunastri, 4, 41, Pl. I, figs. 1–5
Exidia Thuretiana, 55

Femsjonia luteoalba, 2
Fomes robustus, 221
Forays—Haslemere, 2, 221
— Minehead, 1
— Worcester, 2
Fuligo cinerea, 245, 253, 254
— muscorum, 10, 15
— septica, 11, 245, 253, 254
Fumago vagans, 218
Fungi, complete list of, gathered during the forays, 4
— New British Hymenomycetes, 55
— New or rare British Discomycetae, 58
— Notes on new or rare British, 79
— Studies in Discomycetes, III, 293
— Three Fungi Imperfecti, 47
— Two new Basidiomycetes, 50
Fusarium, 25, 99
— Aleyrodes, 96, 156, 164, Pl. V, fig. 12
— Aspidioti, 35, 95, 154, 155, 164, Pl. V, fig. 23
— coccidicola, 35, 94, 95, 106
— coccinellum, 22, 96, 123, 159, 163
— epicoccum, 35, 40, 93, 95, 153, 154, 155, 156, 164, Pl. V, fig. 19
Fusicoccum acuum, 49
— bacillare, 49
— dolosa, 49
Fusisporium coccinellum, 123, 159, 163

Ganoderma applanatum, 3, 221
— australe, 3
— laccatum, 3
— lucidum, 3
— resinaceum, 3
— vegetum, 3
Geaster fimbriatus, 2
Gentiana acaulis, 81
— asclepiadea, 81
— verna, 81
Geotrichum coccophilum, 36
Gloeosporium acerinum, 49
Grandinia tabacina, 57
Graphium penicillioides, 234, 235, 236
Grass, dead stems of, 59

Haddon, Norman G., "Mycetozoa at Porlock in October, 1920," 13
Hapalosphaeria deformans, 84
Haslemere, 2, 221
Helotium lechithinum, 58
— moniliferum, 4
Hemitrichia clavata, 11, 242, 249, 254, 255
— minor, 15
— Serpula, 250, 254, 255
— Vesparium, 11, 249, 254, 255
Heterochaete, 52
— dubia, 52
Heterochaetella, 52, 53
— crystallina, text-fig. 2, 52, 53
— dubia, 52
Hirneola Auricula-Judae, 2
Humaria lechithina, 58
— Oocardii, 296,
Hyalinia, 297
— turgidella, 59
Hyalopus Yvonis, 36
Hyaloscypha candidata, 298
Hygrophorus lacmus, 1
— subradiatus, 1
Hypochnus elaeodes, 57
— granulosus, 3, 57
— lavandulaceus, 57
— roseogriseus, 3, 57
— sphaerosporus, 56
Hypocrella, 30
— cavernosa, 31
— Gartneriana, 32
— phyllogena, 31
— Raciborskii, 31
— scutata, 32
— turbinata, 31
Hypoderma brachysporum, 81
— pinicola, 79
Hypodermella sulcigena, 80, 81

Johnstone, R. B., "Audibility of the spore discharge in *Otidea leporina*," 86
Juniperus communis, 53

Knight, H. H., M.A., "Lichens of Haslemere District," 225
— Review of "A Handbook of the British Lichens by A. Lorrain Smith," 219
— "The Lichens of Minehead District," 16
Kuehneola albida, 4

Lachnum crystallinum, 59
Lamproderma arcyrionema, 12, 248, 253, 255
— columbinum, 14
— violaceum, 14
Larix leptolepis, 85
Lasiobolus macrotrichus, 1
Lecaniascus polymorphus, 36
Lepidoderma tigrinum, 14
Lepiota excoriata, 2
— Friesii, 4
— haematosperma, 4
— nympharum, 4
Leptogium Burgessii, 16
Licea flexuosa, 11, 13, 15
Lichens, by A. Lorrain Smith, F.L.S., 300
— A Handbook of the British, 219
— of Haslemere district, 225
— of Minehead district, 16
Lisea Parlatoriae, 27, 94, 95, 140, 157
Lister, Gulielma, F.L.S., 1
— "Mycetozoa found during the Minehead foray," 10
Lobaria pulmonaria, 16
Lycogala epidendrum, 249, 254, 255

MacCallum, B.D., M.A., D.Sc., F.L.S., "Some wood-staining fungi," 231
Macrosporium, 4
— tomato, 193, 194
Margarita metallica, 251, 254, 255
Marriott, St John, "On the discharge of the peridiolum in Sphaerobolus," 4
Medlar, 287
Medusomyces Givesii, 3
Meetings, 220, 324
Melampsorella Caryophyllacearum, 83
Melampyrum pratense, 83
Melanospora parasitica, 27
Melasmia Empetri, 84
Members, 302
— honorary, 2
Merulius tremellosus, 1
Mespilus germanica, 287
Microcera, 18, 22, 89, 96
— aurantiicola, 22, 110, 112, 136, 158, 163
— coccidophthora, 112, 160, 163
— coccophila, 19, 20, 21, 22, 89, 90, 91, 93, 95, 99, 100, 109, 110, 111, 112, 113, 115, 117, 118, 120, 122, 123, 124, 128, 129, 135, 152, 159, 163
Microcera curta, 25, 35, 95, 99, 155, 164
— Fujikuroi, 23, 95, 99, 100, 101, 105, 157, 164
— Henningsii, 157, 164
— Merrillii, 23, 95, 99, 100, 106, 157, 164
— Mytilaspis, 24, 94, 95, 100, 141, 142, 143, 161, 165
— Parlatoriae, 25, 35, 94, 95, 99, 154, 164
— pluriseptata, 21, 96, 100, 113, 123, 159, 163
— rectispora, 25, 92, 93, 95, 100, 152, 165
— tasmaniensis, 24, 94, 95, 100, 141, 142, 143, 161, 165
— Tonduzii, 25, 35, 95, 99, 155, 164
Milesina Blechni, 3
— Dieteliana, 3
Minehead, 1
Molinia caerulea, 82, 83
Mollisia caesia, 297
Mounce, Irene, M.A., "Homothallism and heterothallism in the genus Coprinus," 256
— "Homothallism and the production of fruit-bodies by monosporus mycelia in the genus Coprinus," 198
Mucronella aggregata, 58
Mycetozoa, at Porlock in October, 1920, 13
— List of, 10
— Notes on Malayan, 239
Mycorhiza in orchids, 3
Mycosphaerella citrullina, 173, 174, 175, 188, 189, 190, 196
Myriangium, 33
— Acaciae, 33
— Duriaei, 1, 33, 123

Naemaspora Strobi, 49
Nectria aglaothele, 19, 20, 92, 95, 97, 110, 111, 120, 159
— aurantiicola, 19, 21, 92, 94, 95, 97, 99, 110, 111, 112, 113, 114, 124, 127, 130, 131, 152, 158
— barbata, 25, 96, 140, 158, Pl. III, fig. 14, Pl. V, figs. 4–6
— coccicida, 122
— coccicola, 143, 161
— coccidophthora, 19, 94, 95, 97, 110, 111, 113, 129, 130, 131, 132
— coccogena, 23, 24, 92, 95, 135, 157, Pl. V, fig. 18
— coccophila, 24, 94, 95, 136, 157
— coccorum, 23, 24, 92, 95, 134, 135, 157
— Colletiae, 110

Nectria diploa, 24, 96, 97, 100, 133, 134, 135, 137, 157, 164, Pl. III, fig. 13, Pl. V, fig. 22
— episphaeria, 91, 109, 128, 129
— guaranitica, 133
— haematococca, 124
— laeticolor, 20, 96, 97, 112, 113, 120, 133, 159
— longispora, 157
— minuta, 133
— muscivora, 20, 110, 111, 116, 118, 119, 120, 121, 159
— myrticola, 96, 135, 157
— oidioides, 96, 135, 157
— Passeriniana, 20, 22, 96, 121, 159
— Ralfsii, 122
— sanguinea, 121
— subcoccinea, 20, 96, 97, 110, 111, 121, 159
— Tuberculariae, 25, 96, 138, 140, 157, 163, Pl. IV, fig. 8, Pl. V, fig. 9
— variabilis, 24, 95, 137, 157
— viticola, 121
Nephromium lusitanicum, 16
Niptera Taxi, 60

Oak stump, 56
Oidium alphitoides, 4
Ophionectria, 26, 144
— Aurantii, 151
— coccicola, 25, 26, 92, 93, 94, 95, 139, 143, 144, 145, 146, 149, 150, 151, 161
— tetraspora, 26, 95, 144, 150, 151, 152, 162
— trichospora, 144
Orbilia flexuosa, 297
Orchis latifolia, 82
Otidea leporina, 86
— violacea, 298

Pachyella depressa, 3, 296
Paepalopsis deformans, 84
Pannaria, 16
Parmeliella, 16
Patouillardiella Aleyrodis, 96, 154, 163
Paulson, R., F.L.S., Review of "Lichens," by A. Lorrain Smith, 300
— "The sporulation of gonidia in the thallus of *Evernia prunastri*," 4, 41
Paxillus panuoides, 3
Pearson, A. A., F.L.S., "New British Hymenomycetes," 55
Penicillium coccophilum, 36
— crustaceum, 294
Peniophora accedens, 51
— aegerita, 54
— argillacea, 53
Peniophora chordalis, 53
— cineracea, 52
— clavigera, 53
— detritica, 53
— glebulosa, 51, 52
— laevis, 57
— sphaerospora, 57
— subalutacea, 52
— sublaevis, 50
Perichaena chrysosperma, 251, 254, 255
— depressa, 11, 251, 254, 255
— vermicularis, 242, 251, 254, 255
Pestalozzina Rollandi, 48
Petch, T., B.A., B.Sc., 1
— "Fungi parasitic on scale insects," 2, 18
— "Studies in entomogenous fungi," 89
Peziza caesia, 297
— diplocarpa, 295
— lechithina, 58
— turgidella, 59
— vesiculosa, 275
Pezizella turgidella, 59
Phaeographis dendritica, 16
Phallus imperialis, 3
— impudicus, 275, 276, 277, 278, 283
Philonectria variabilis, 95
Phoma abietina, 79
— alternariaceum, 192, 193, 196
— destructiva, 173, 190, 196
— Lycopersici, 175, 189, 190, 191, 196
Phomopsis Tulasnei, 49
Physarella oblonga, 246, 253, 254
Physarum aurantium, 244, 253, 254
— auriscalpium, 240, 244, 253, 254
— bitectum, 11
— columbinum, 244, 253, 254
— compactum, 244
— compressum, 254
— fulvum, 253, 254
— incanum, 244, 253, 254
— lateritium, 245, 253, 254
— leucopus, 10
— melleum, 243, 253, 254
— nucleatum, 240, 245, 253, 254
— nutans, 242, 244, 300
— psittacinum, 253, 254
— pusillum, 245, 253, 254
— reniforme, 245, 253, 254
— rigidum, 244, 246, 253, 254, 299
— virescens, 245, 253, 254
— viride, 244, 253, 254, 299
Picea excelsa, 79, 233
Pilobolus, 61
Pinus Cembra, 83
— Lambertiana, 83
— monticola, 83
— nana, 81
— ponderosa, 231, 232

Pinus Strobus, 81
— sylvestris, 47, 49, 51, 52, 53, 57, 58, 61, 79, 232, 233
Pleurococcus, 43
Pleurotus corticatus, 4
Podonectria, 27, 143, 146, 161
— Aurantii, 27, 146, 149, 151, 152, 162, 165, Pl. IV, fig. 10, Pl. V, fig. 14
— coccicola, 27, 146, 153, 161, 165, Pl. IV, fig. 9, Pl. V, figs. 1–3, 15
— coccophila, 146
— echinata, 27, 96, 146, 151, 162, 165, Pl. IV, fig. 7
Podosphaera myrtillina, 1
Polygonum viviparum, 82
Poria sanguinolenta, 2
Presidents
— Petch, T., B.A., B.Sc., 2, 18
— Rea, Carleton, B.C.L., M.A., 1
Proceedings, 220, 302
Protococcus, 44, 46
— viridis, 43, 45
Pseudomicrocera, 23, 24, 97, 99, 100, 164
— Henningsii, 23, 24, 100, 135, 136, 137, 157, 164, Pl. III, figs. 9–12, Pl. V, figs. 8, 17, 20, 21
— longispora, 100, 107
Pseudotsuga Douglasii, 85
Puccinia Absinthii, 3
— Anthoxanthi, 83
— Brunellarum-Moliniae, 83
— dispersa, 82
— Epilobii, 221
— Gentianae, 81
— glumarum, 72
— Millefolii, 81
— Moliniae, 3, 82, 83
— nemoralis, 83
— Pazschkei, 81
— secalina, 82
— septentrionalis, 82
— Tritici, 72
— triticina, 73
Pustularia catinus, 4
— lecithina, 58
Puttemansia, 26, 94, 145
— Aurantii, 26, 94, 95, 146, 149, 162
— coccicola, 161
— lanosa, 145, 146

Ramsbottom, J., M.A., F.L.S., O.B.E., 1
— "Californian Bees," 86
— "Diamond spot," 4
— "Ginger Beer Plant," 3, 86
— "Medusomyces Givesii," 3
— "Mycorhiza in Orchids," 3
Rea, Carleton, B.C.L., M.A., 1
— "Error in Boudier's micrometric measurements," 218
— "New or rare British Discomycetae," 58
— "The genus Ganoderma," 3
Reticularia Lycoperdon, 249, 254, 255
Rhytisma Empetri, 85
Rubus fruticosus, 84
Rules, 314
Russula heterophylla, 278, 283
— incarnata, 2
— nigricans, 278, 279, 280, 281, 283

Saccharomyces pyriformis, 87
Sanderson, A. R., F.L.S., "Notes on Malayan mycetozoa," 239
— "On the parasitic habits of the plasmodium of *Physarum viride* var. *rigidum* Lister," 299
Saxifraga Aizoon, 81
— Cotyledon, 81
— cultrata, 81
— Hostii, 81
— longifolia, 81
— rhaetica, 81
Schizophyllum commune, 199, 200, 214, 256, 258, 264, 265, 268, 269
Scleroderris gigaspora, 26, 95, 149, 161
Sclerotinia Ariae, 287
— cinerea, 289
— fructigena, 289
— laxa, 289
— Mespili, 287, 291, 292, 293
Scoleconectria, 26, 144, 145
— coccicola, 161
Searle, G. O., B.Sc., "An investigation of some tomato diseases," 173
Sebacina, 53, 55
— ambigua, 55
— caesia, 55
— cristata, 55
— fugacissima, 56
— incrustans, 55
— sebaceum, 55
Secretary, General, 1
Septobasidium, 34
— pedicellatum, 34
— rameale, 34
Septoria thecicola, 2
Slugs as mycophagists, 270
Sphaeria clavulata, 28
— muscivora, 117
— pseudovillosa, 113
Sphaerobolus stellatus, 4
Sphaeronema Lycopersici, 191
Sphaerostilbe, 19, 91, 109, 114, 115
— aurantiaca, 114

Sphaerostilbe aurantiicola, 21, 22, 35, 40, 111, 112, 114, 116, 123, 124, 128, 129, 131, 136, 137, 154, 156, 158, 163, Pl. III, figs. 1–5, Pl. V, figs. 10–11, 16
— cinnabarina, 114
— coccidophthora, 21, 22, 112, 113, 114, 120, 129, 136, 160, 163, Pl. III, fig. 6.
— coccophila, 19, 21, 93, 95, 109, 110, 111, 112, 118, 121, 123, 127, 128, 129, 136, 158, 159
— flammea, 19, 20, 21, 22, 35, 40, 96, 97, 99, 111, 112, 113, 114, 115, 118, 119, 120, 121, 122, 123, 124, 136, 159, 163, Pl. III, figs. 7–8
— gracilipes, 114
— repens, 113, 114
— variabilis, 114
Spiraea ulmaria, 60
Spores, audibility of the discharge in *Otidea leporina*, 86
— "audibility of the 'puffing' in the larger Discomycetes," 4
— error in Boudier's measurements, 218
— longevity of, 217
Sporotrichum globuliferum, 36
— Lecanii, 36
Stellaria Holostea, 83
Stemonitis ferruginea, 15, 247, 253, 255
— flaccida, 11
— fusca, 247, 253, 255
— herbatica, 15
— hyperopta, 12, 13
— splendens, 11, 247, 253, 255
Stemphylium, 4
Stereum Karstenii, 50
— purpureum, 50, 214
Sticta, 16
Stilbum, 18
— coccophilum, 36
— flammeum, 20, 91, 115, 118, 159
Synechoblastus nigrescens, 16

Taxus baccata, 60
Tetracium, 25, 94, 100, 145
— Aurantii, 26, 94, 95, 145, 146, 162, 165
— coccicola, 145
— coccicolum, 161, 165
— echinatum, 162, 165
— rectisporum, 152, 165
Thalictrum alpinum, 82
Thecospora Vacciniorum, 1
Thelotrema lepadinum, 16
Tomato diseases, 173
Torrubiella, 27
— brunnea, 27
— Lecanii, 27
— luteorostrata, 27
— rubra, 27
Treasurer, 2
Tremella epigaea, 55
Trichamphora, pezizoides, 246, 253, 254
Trichia affinis, 249, 254, 255
— Botrytis, 11, 249
— cerifera, 11
— decipiens, 249
— favoginea, 12
— floriformis, 11
— persimilis, 249, 254, 255
— varia, 242, 249
Tricholoma columbetta, 2
Trichopeziza caesia, 297
Tubercularia ciliata, 115
— coccicola, 25, 95, 139, 158, 163, Pl. IV, figs. 5–6
Tubifera ferruginosa, 249, 253, 255
— stipitata, 249, 253, 255

Urceolella deparcula, 60
— leuconica, 298
Uredo Scolopendri, 3
Urocystis Cepulae, 65, Pl. II, figs. 1–18

Verticillium heterocladum, 36
Vice-Presidents
— Lister, Gulielma, F.L.S., 1
— Petch, T., B.A., B.Sc., 1
Volutella ciliata, 115

Whitehead, T., A.R.C.S., "On the life history and morphology of *Urocystis Cepulae*," 65
Wilson, Malcolm, D.Sc., F.L.S., F.R.S.E., "Notes on new or rare British fungi," 79
Wood, 56, 58
Wormald, H., "Observations on a Discomycete found on Medlar fruits," 287

Xylaria clavulata, 28

Zygodesmus granulosus, 57

ERRATA.

p. 104, line 38, *for* Pl. IV *read* Pl. III.
p. 117, line 27 *for* 80 *read* 86.
p. 118, line 7, *for* Moquolia *read* Magnolia.
p. 154. The section on Patouillardiella, lines 21–34, should precede Fusarium; p. 153, line 35, p. 154, *et seq.*, refer to Fusarium.

---

## PROCEEDINGS, 1921.

MEETING. UNIVERSITY COLLEGE, LONDON. *November 19th.*

Dr G. R. Bisby. The use of fungicides on potatoes in North America.
Dr W. Brown. The growth of fungi in culture.
Mr W. N. Edwards. An Eocene Microthyriaceous fungus from Mull, Scotland.
Professor Dame H. C. I. Gwynne-Vaughan. The grouping of the simpler Ascomycetes.
Dr A. S. Horne. Fungi from a diseased Hevea trunk.

PRINTED IN ENGLAND BY J. B. PEACE, M.A. AT THE CAMBRIDGE UNIVERSITY PRESS